

## Images confirm records of Fijian orca (*Orcinus orca* Linnaeus, 1758), including a group with indistinct saddle patches

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### ABSTRACT

We collated ( $n=36$ ) records of orca (*Orcinus orca* Linnaeus, 1758, also known as the killer whale (Cetacea Delphinidae) in the waters of the Republic of Fiji, South Pacific Ocean. Using standardised criteria, we classified these records into *Confirmed*, *Presumed* and *Unconfirmed*. We then conflated replicated records to create ( $n=12$ ) unique meta-records between 1994–2024. We confirm, for the first time with photographs/video, the species as present in Fijian waters with evidence (photos/video) for ( $n=6$ ) records between 2006–2024 which illustrate species-specific characteristics. From within that dataset, we report on a group of five orca which had either extremely faint ‘belt’ shaped saddle patches, or no saddle patches. Based on this pigmentation anomaly we consider that they may be an aberrant group or belong to a previously undescribed tropical ecotype.

### KEY WORDS

Cetacean; citizen science; colouration; killer whale; ecotype; geographic variation; pigmentation; saddle patch; social media; tropics.

Received 13.05.2024; accepted 06.07.2024; published online 30.09.2024

### INTRODUCTION

The identification of species, and variations within a species, are two of the fundamental building blocks for understanding biodiversity (Reaka-Kudla et al., 1997). Characteristics such as body morphology and pigmentation are key features used in field identification of cetaceans (e.g., see Jefferson et al., 2015), including variations between ecotypes (Ford, 2018).

The largest species of the Delphinidae, the orca (*Orcinus orca* Linnaeus, 1758, also known as the

killer whale), has a number of characteristics helpful for identification during field observations, *inter alia* the sexual dimorphism of the dorsal fin, such that for females it is less than 0.9 m tall and frequently falcate whilst “Among adult males, the dorsal fin is triangular and may reach 1.8 m in height” (Heyning & Dahlheim, 1988). Scammon (1874) noted the species had “An extremely prominent dorsal fin, ... [which] distinguishes it from all other Dolphins.”

Orca have been described as “... one of the most strikingly pigmented cetaceans... making field iden-

*tification easy*” (Heyning & Dahlheim, 1988), with distinguishing characteristics including the overall upper body pigmentation which is typically black (Ford, 2018) or shades of grey (Visser, 1999), with white flank fields (Ford, 2018), white post-ocular patches (commonly termed eye patches, Visser & Mäkeläinen, 2000) and patches of grey found posterior to, or partially under, the dorsal fin (Sugarman, 1984). These grey patches are commonly referred to as ‘saddle’ patches in reference to their location being similar to the position in which a saddle is placed on equines (Greve & Dyson, 2014). The shape of the saddle patch pigmentation is variable enough that with high-resolution images of this pigmentation, each individual can be uniquely identified (Bigg et al., 1987). This variation differs subtly or distinctly between both sides of an individual (Bigg, 1982; Bigg et al., 1987; Mäkeläinen et al., 2013), although at times there are also similarities between individuals within groups (Sugarman, 1984; Baird & Stacey, 1988; Baird et al., 2006).

The saddle patches of this species have been classified into different shapes by various authors, such as Evans & Yablokov (1978) who illustrated 16 shapes from free-ranging orca around the world and those in captivity in the USA, Sugarman (1984) who described five shapes from a population found along the coastline of the Pacific North West, and Mäkeläinen et al. (2024) who described six shapes from 48 geographically or ecologically divided groups/populations/ecotypes, in four Ocean Basins. With such variation, saddle patches may at times help define orca populations/ecotypes (Sugarman, 1984; Baird & Stacey, 1988; Mäkeläinen et al., 2024).

With this publication we aimed to confirm the species in the waters of the Republic of Fiji (hereafter referred to as Fiji) through standardising all the sighting records (see Material and Methods for details). Additionally, we describe the saddle patches from a group observed in 2006 which may be either an aberrant morph or be individuals who belong to a previously undescribed tropical ecotype.

## MATERIAL AND METHODS

### *Sightings within Fijian waters*

We collated sighting records (hereafter referred to as records) of orca in Fijian waters by;

A) using standard scientific search engines for peer reviewed published and ‘grey’ records (i.e., reports, newspapers, magazines, newsletters, etc) collectively hereafter termed Published records;

B) searching online media such as video platforms (e.g., YouTube, Vimeo and TikTok), photo sharing websites (e.g., Flickr and Dronestagr.am), informational websites (e.g., Governmental and NGO’s), wildlife data-sharing website/apps (e.g., iNaturalist.com and JungleDragon.com) and social media (e.g., Facebook and Instagram), collectively hereafter termed Other Media and;

C) records from the authors observations/databases, collectively hereafter termed Authors Databases. Following Visser et al. (2023), when a record was reported more than once (by the same or different sources), we conflated these into a meta-record, thereby consolidating the data.

Where feasible, we contacted the original authors/observers to obtain original/additional information/photos/video. Where the date of a record could not be specifically ascertained, we assigned it as the date of publication/posting online, although we recognised that the encounter may have occurred well prior to the date of publication/posting. Where a record described the location as just ‘Fiji’ or ‘Fijian waters’ or similar (i.e., with only the generic location of the country), we included it in the dataset but did not plot it on the map.

### *Record Standardisation and Species Identification*

We classified the records into (a) *Confirmed* (records which had photos and/or video) (b) *Presumed* (records with no photos/video but from observers who had experience with the species and/or who were experienced with marine life and/or who described a characteristic which left no doubt as to the species - such as very ‘tall dorsal fin’) and (c) *Unconfirmed* (records which did not fall into the previous two categories but which included comments that the species had been sighted).

Where video was available, we extracted frames containing characteristics which would contribute towards species identification. We assessed photos/video (collectively referred to as imagery) for quality attributes (Table 1). When categorising an image, it was classified according to its lowest ranking, e.g., the individual may be in focus and fill 50%

of the frame (i.e., characteristics for *Good*), but it may be backlit (i.e., a characteristic for *Reasonable*), in which case the image would be classified as *Reasonable*.

We only used those images which were of *medium* or *high* resolution and *Good* or *Reasonable* quality to assess species identification. In order to confirm they were orca we used a range of field identification features as indicated by Heyning & Dahlheim (1988). We noted variations in these features within and between records, in particular focusing on the 2006 record (see details below).

**2006 Record Details**

During an eco-tourism expedition, two of the authors (DC, GM) documented a group of orca in the waters of Fiji. DC used a SLR digital Canon EOS 10D (6.3MP) camera with a 100–400 mm lens, whilst GM used a SLR digital Nikon D70 (6MP 3000x2000px) camera with a Nikkor 75–300 mm lens. In the era of the encounter (i.e., 2006), SLR digital cameras produced relatively low-resolution images, of just a few megapixels (i.e., our category *Medium*) and sensor technology was limited to a rel-

atively low dynamic range that can make it more difficult to distinguish between low contrast areas of a photo (i.e., our category *Reasonable*). Where possible we used RAW images (i.e., a format which uses uncompressed data from the camera sensor) as these were lossless compared to jpg (jpeg) files which are compressed. If an image was only available in *low* or *medium* resolution, in order to improve photo quality (e.g., resolution and sharpness) and so as to produce images for better comparison and reproduction, we applied software algorithms from Photoshop 2023, TopazLabs Stabilize AI and Gigapixel AI, following Visser et al. (2022). We note that those authors recommended caution when applying such machine learning tools, in order to avoid aberrations or the creation of artefacts or ‘new’ features. Therefore, we applied the algorithms minimally and in a series of upscaling iterations to ensure that there was no overtly discernible aberrations or artefacts between the original images (of relatively low resolution) and those which we used herein. To retain referential integrity to the other images in the data set, and despite these improvements in the image quality, we did not then upgrade these images in our classification.

Categories	Levels	Criteria/Notes
<u>Photo</u> Resolution/Size	<i>Low</i>	≤ 1 mb
	<b><i>Medium</i></b>	Between 1.1 and ≤9.9 mb
	<b><i>High</i></b>	≥ 10 mb
<u>Video</u> Screen Capture	<i>Low</i>	Image is pixelated and features hard to discern or only 1 feature is visible
	<b><i>Medium</i></b>	Image illustrates at least two species-specific features clearly
Resolution	<b><i>High</i></b>	Image illustrates multiple species-specific features clearly and ≥3 images were extracted of this quality from the video(s) from that record
<u>Photo &amp; Video</u>	<i>Poor</i>	Imagery out of focus and/or animal ‘tiny’ in frame and/or high contrast and/or difficult to ascertain features
Quality	<b><i>Reasonable</i></b>	Imagery in focus and animal ≥25% of frame and/or some areas of contrast may be poor and/or excessive and/or (if video), the animal may move in and out focus but is clearly discernible and/or may move in and out of glare/backlighting
	<b><i>Good</i></b>	Imagery in focus and animal is clearly discernible and features were clear, and/or minimal glare and/or not backlit irrespective of % of frame used by animal

Table 1. Quality attributes used to classify the photograph/screen capture from video evidence. Only the Levels in bold were used to assess species identification.

RESULTS

*Sightings within Fijian waters*

We found ( $n=36$ ) records from the Published, Other Media and Authors Databases of orca in Fijian waters, all falling between 1994–2024, (Sup-

plemental Material SM1). When conflated we had ( $n=12$ ) meta-records (Table 2, Fig. 1), with the most common group size being ( $n=5$ ), Table 2.

Within the Published category there were ( $n=20$ ) documents which reported orca in Fijian waters (SM1), which when conflated resulted in ( $n=3$ ) records. Two gave an approximation of

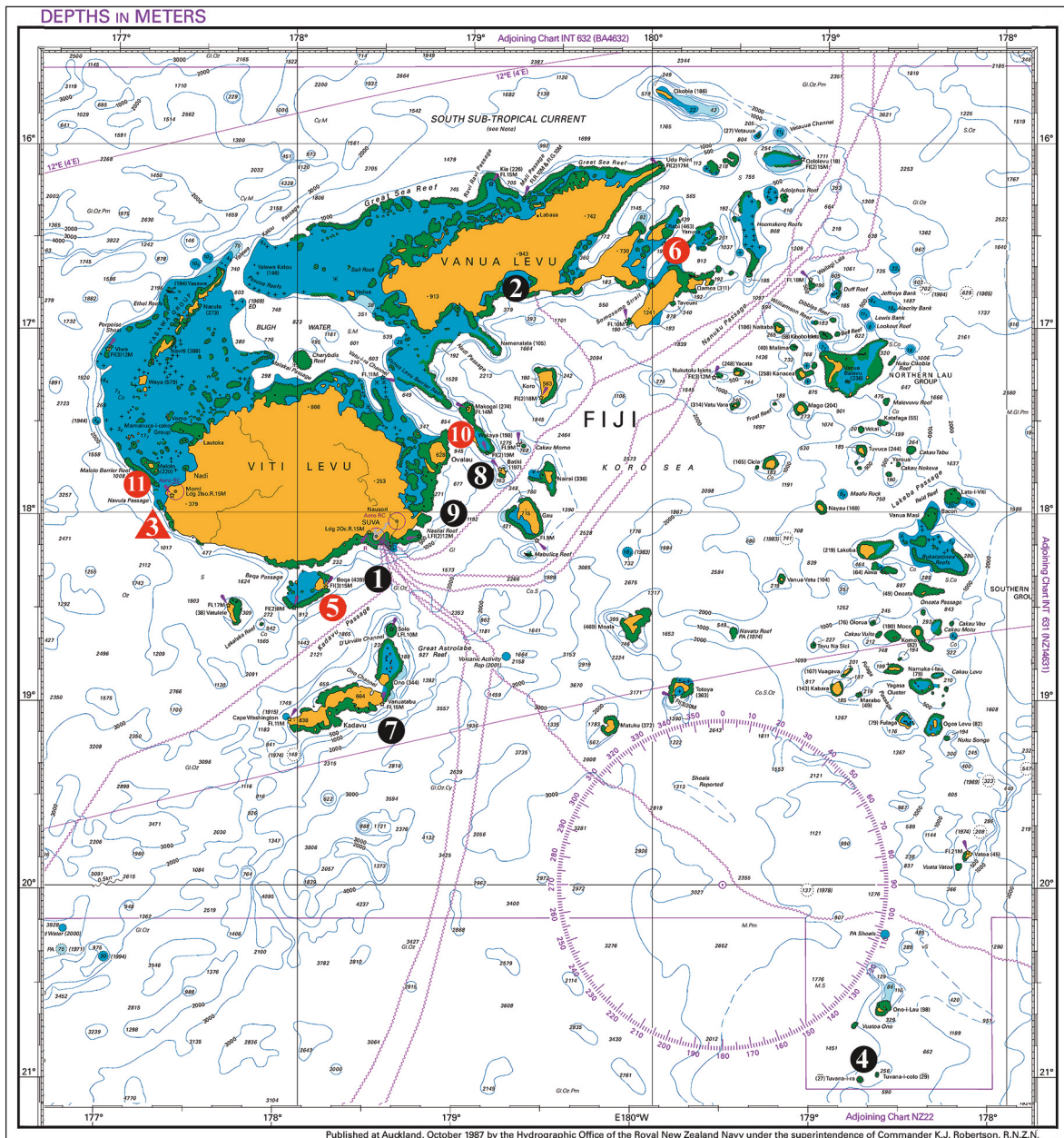


Figure 1. An extract from the nautical chart number NZ1438, with 11 records of orca in Fijian waters where location was specified (i.e., Record #12 is not illustrated, as only a general reference to Fiji was provided). Those records indicated in black are Unconfirmed or Presumed, those in red are Confirmed. Record #3 is indicated with a ▲ and is the 2006 sighting discussed in detail herein. See Table 2, SM1 and SM3 for corresponding record numbers and additional details.



Record #	Date (YYYY MMDD)	Location within Fiji**	Record Source / Type	Imagery Type	Original / Additional data	Imagery Resolution	Imagery Quality	# of orca**	Imagery Confirms Species	Saddle patches	Source
1	1994	Near Suva	Published <i>Presumed</i>	Unknown	NO	N/A	N/A	5 - 8	N/A	N/A	Anon (1995)
2	2002	Savusavu Bay	Other Media <i>Unconfirmed</i>	None	NO	N/A	N/A	5	N/A	N/A	Kesa (Sunny) Bill
3	20060914	SW of Viti Levu	Published & Authors Databases <b>Confirmed</b>	Photographs	YES	Medium	Reasonable	5	YES	Very faint on x2	David Cothran & Gerald McCormack
4	2010 (or pre)	Waters surrounding Tuvana Island, Lau group	Published <i>Presumed</i>	Unknown	NO	N/A	N/A	?	N/A	N/A	Miller et al. (2016)
5	20150816	East of Beqa Island	Other Media <b>Confirmed</b>	Video	YES	High	Reasonable	3	YES	Yes (grey)	Paddy Todd (Lily G III)
6	20200312	Tavenui (Somosomo Strait)	Other Media <b>Confirmed</b>	Video	YES	Medium	Reasonable	5	YES	Yes (grey)	Colleen O'Neill (Tavenui Palms Resort)
7	Pre 20200507	Kadavu	Other Media <i>Unconfirmed</i>	Unknown	NO	N/A	N/A	?	N/A		Kesa (Sunny) Bill
8	Pre 20200507	Wakaya Island	Other Media <i>Unconfirmed</i>	Unknown	NO	N/A	N/A	?	N/A	N/A	Jone Salele Uluiviti
9	20230710	West/NW of Nasilai	Authors Databases <i>Presumed</i>	Unknown	NO	N/A	N/A	3	N/A	N/A	Paddy Todd (Lily G III)
10	20230726	10 miles South of Makogai Island	Other Media <b>Confirmed</b>	Video	YES	Medium	Reasonable	2 groups	YES	Yes (grey)	Niels Eikenboom & Greetje Tops (Sailing Black Moon)
11	20231228	Namotu Island	Other Media <b>Confirmed</b>	Video	YES	Medium	Reasonable	5	YES	Yes (grey)	Namotu Island, Emmanuel Markham & Carlos Andres
12	20240211	Fiji	Other Media <b>Confirmed</b>	Video	NO	High	Good	12	YES	Yes (grey)	LibertyBliss

Table 2. Summary of (n=12) orca sightings in Fijian waters. Record # corresponds to those in Fig. 1 and details in Supplemental Material 1–3. Record #3 is the 2006 sighting reported in detail herein. \*\* = details as described by source, N/A = not applicable, Original / Additional data refers to the authors obtaining the original imagery and/or being provided additional information from the source.

sighting date (“late last year [i.e., 1994]” record #1 and “2010” record #4) and they both provided a location (SM1; “near Suva” record #1 and “waters surrounding Tuvana Island, Lau group” record #4, however see SM2 for information regarding the latter), therefore these were plotted (Fig. 1). The third Published record (#3, Table 2) was mentioned in passing in both Dwyer & Visser (2011) “images of orca from .... Fiji, ... (Visser, unpub. data)” and Mäkeläinen et al. (2024) “All

saddle patches in the Republic of Fiji geographic group belonged to the ‘Other’ category as there were either no saddle patch shapes or they were indefinable”. Neither gave a date or specific location, but the latter did state the group size as five. The data within both these publications was sourced from the Authors Databases and it is the same 2006 record discussed herein, (i.e., record # 3 Table 2). As such, these two publications contribute to the meta-record for that sighting (SM1)

where it is listed as both Published and Authors Databases (Table 2). Only one other record (#1) provided group size (“schools of between five and eight”) and it also “estimated their lengths at between 8 and 10 meters (26 to 33 ft)”. None of the Published records provided further information such as behaviour details. Furthermore, none included any imagery, therefore they would not fit the criteria for classifying the species as *Confirmed*.

Within the Published records there were various inconsistencies, ambiguities and anomalies (e.g., (i) referencing the species as ‘confirmed’ when no evidence was provided; (ii) listing the species as both ‘confirmed’ and ‘unconfirmed’ in the same document and/or; (iii) citing a source and a secondary source as separate records within the same publication, see SM2 for details and further examples). To prevent further irregularities, we applied a standardised system to categorize records including using the criteria of imagery for confirmation of the species. Although we recognise that some authors, such as Miller et al. (2016), listed the species as ‘confirmed’, when utilizing our standardised classification criteria, that Published record would become *Presumed* as there was no imagery provided (nor referenced, instead the ambiguous term “visually documented” was used). When applying the same criteria to all Published records, none were confirmed orca in Fijian waters.

Within the Other Media there were ( $n=14$ ) records, which when conflated resulted in ( $n=8$ ) meta-records from between 2006–2024 (Table 2, Fig. 1). There were ( $n=2$ ) records from the Authors Databases, one each from 2006 and 2023. Only Other Media and Authors Databases included any imagery (Tables 2, 3 and SM1). None of the media contained metadata such as geotagged location and as such this was ascertained by either the accompanying text or via direct communication with the observer(s). Those records with imagery all had *medium* or *high* resolution as well as *Reasonable* or *Good* quality (Table 2). In all those records (excluding the 2006 record, see details below) the orca had grey saddle patches (SM3). Only one record (#11) had information potentially linked to diet, where the orca “seem to have been feeding with the yellow fin tunas we were catching” (Emmanual Markham, pers. comm., 21 April 2024).

### **Record Standardisation and Species Identification**

Six records included imagery (one had photographs and five had video, Table 2, SM3) and all six were from Other Media or Authors Database. All had at least one image which was *Medium* or *High* resolution and *Reasonable* or *Good* quality (Table 2). As such, based on the features listed in Table 2 they could be unequivocally identified as *Orcinus orca* in all six records and therefore the species could be *Confirmed* in Fijian waters with evidence and in multiple instances and locations (Table 2).

Although we made no matches between any of the records it is possible, but not certain, the adult male in Record #5, which had a rounded notch out of the trailing edge of his dorsal fin (Fig. 5.4 in SM3), is the same adult male as in Record #10 (Fig. 10.2 in SM3), based on what appears to be a notch of similar shape, size and position on the trailing edge of his dorsal fin. However, in both cases the resolution of the imagery was not sufficient for confirmation. But, if it is the same male, he was resighted 2,901 days (7 years, 10 months and 11 days) and ~130 km apart.

### **2006 Encounter Details**

On 14 September 2006 at 06:08 hrs, five cetaceans were observed travelling as a group off the south-west coast of Viti Levu, Fiji, (Latitude 18° 02' S, Longitude 177° 11' E) (Fig. 1, Table 2, Record #3). The observation platform was an ‘expedition cruise’ ship ~90 m in length, travelling at ~18 km/hr, in a south-easterly direction. The sighting was ~10 km from the edge of the coastal reef (Fig. 2) and ~20 km from the entrance to Likuri Harbour, where the low tide was approximately 0.26 m in height at 05:30 hrs on that day. Tidal data extracted from NOAA Tides & Currents website, for this date and at Tailevu, the Island of Viti Levu, Republic of Fiji: <https://tinyurl.com/VitiLevuTides>. The water at the sighting location was ~1,600 m deep. Sunrise was at 06:05 hrs and at the time of the encounter the sun was at a heading of 82° and had between 12° to 16° of altitude: <https://tinyurl.com/VitiLevuSunrise>. There was >10% cloud cover and the sea state was Beaufort 2. The orca were pho-

tographed from an observer height of ~10 m from the port decks.

The animals were travelling in a generally synchronous formation with multiple members of the group at the surface at any one time (Figs. 3–7). They were travelling parallel to the ship and the coastline. After travelling alongside the vessel, they veered off from the course of the ship and two were photographed from slightly behind (Fig. 3). During the encounter the orca were observed for ~10 minutes but for photography purposes they were only within the range of between ~30–40 m from the vessel for a few minutes. As such, only five images were available for assessment (Figs. 3–7). The number of animals photographed ( $n=5$ ) matched the number observed.

The five cetaceans were confirmed to be orca based on the morphological and pigmentation fea-

tures noted in Table 3 (and see Figs. 3–7 and SM3 for examples). With estimated body lengths of between 6 to 8 m, as well as the size and shape of their dorsal fins, four of the orca (#1, #2, #3 and #4 as labelled in Figs. 4, 5), were either adult females or subadult males. One orca (#5, as labelled in Figs. 4, 5, 7) was larger than the others and had the characteristic sexually-dimorphic tall dorsal fin of an adult male (see Dahlheim & Heyning, 1999 and Ford, 2018 for differences between the age and sex classes). Orca #1, 2, 3 and 4 all had notches of various sizes out of the trailing edge of their dorsal fin (see SM3 for details).

Three of the orca (#1, #3, #5 as labelled in Figs. 4, 7) were documented with white eye-patches characteristic of the species. The eye-patch of orca #1 would be classified into the category of ‘Hook & Bump’ shape (Visser & Mäkeläinen, 2000),

Morphology Field Characteristic	Characteristics found on Orca from 2006 Fiji encounter # = allocated number for each individual as indicated in Figs. 3–7
“robust body”	#1, #2, #3, #4, #5
“Female killer whales generally attain a body length of 7.0 m and males 8.2 m; however, maximum lengths of 8.5 m for females and 9.8 m for males have been reported”	#1, #2, #3, #5
“... head is blunt with virtually no distinguishable beak”	#1, #2, #3
“... proportionately higher dorsal fins than other large delphinids, ranging from one tenth to one-fifth of the total body length”	#1, #2, #3, #4, #5
“Among adult males, the dorsal fin is triangular and may reach 1.8 m in height”	#5
“... in adult females and young males it [the dorsal fin] is less than 0.9 m tall and distinctly falcate”	#1, #2, #3, #4
Pigmentation Field Characteristic	
“... dark, usually jet black, dorsally” NOTE 1	#1, #2, #3, #4, #5
“... postocular white spot”	#1, #3, #5
“... white region typically extends from the entire lower jaw posteriorly”	#3
“A highly variable gray or white saddle is usually present posterior to the dorsal fin”	See text & Fig. 3-7
“Individual and geographical variation in the pigmentation pattern exists”	#1, #2, #3, #4, #5

Table 3. A range of morphological and pigmentation field identification features for *Orcinus orca*, as described by Heyning & Dahlheim (1988) and the references therein. The five orca documented and observed in Fijian waters in 2006 exhibited various combinations of these characteristics. See text for further details and Figs. 3–7 for examples and individuals as labelled by #1–#5). NOTE 1. A number of populations of orca have been described since the Heyning & Dahlheim (1988) publication, including some which have predominantly grey body pigmentation (e.g., see Visser, 1999).

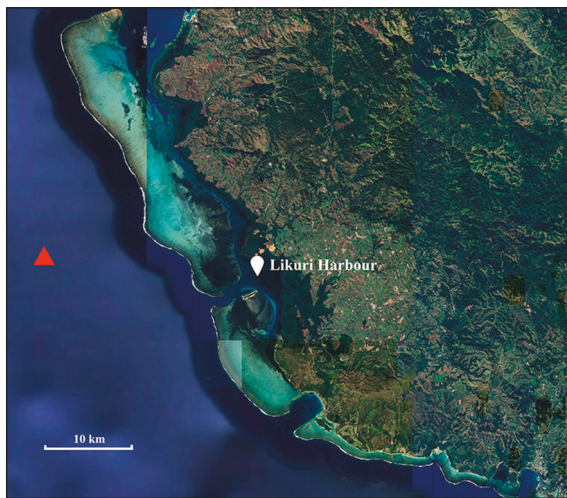


Figure 2. The sighting location (red triangle), in relation to the proximity to the coral reef and Likuri Harbour, Viti Levu, Fiji. Extracted from Google Earth. See Fig. 1 for site location in relation to the other sightings and for context within the Fijian archipelago.

whilst the other two orca (#3 & #5) did not have the anterior edge of the eye-patch visible in the photographs and therefore could not be classified. All three eye-patches were medium size and had a parallel orientation (see Visser & Mäkeläinen, 2000, for details regarding this orientation). The right white mandible and chin of one orca (#3, as labelled in Fig. 7) were visible through the water as it surged forward.

All five orca lacked a clearly demarcated and typical “gray or white” saddle-patch (as defined by Heyning & Dahlheim, 1988) see Figs. 3–7. Two of the five orca had an area of extremely faint pigmentation in the general area where a saddle patch would be expected (Fig. 3). That pigmentation appeared to extend downwards in a wide ‘belt’ shape. However, given the very diffuse edges of the pigmentation it was not possible to determine where the ‘belt’ ended as it progressed downwards over the dorso-thorax towards the ventral area of the animals. The colour of the pigmentation was opaque and only slightly distinguishable from the surrounding black and only noticeable when the animals were photographed behind from an oblique angle (i.e., it was not visible on any of the photographs taken perpendicular to the orca, Figs. 4–7). As such, we were not able to identify which two of the five Fiji orca had this indistinct pigmentation.

Furthermore, it cannot be ascertained if the remaining three orca had faint ‘belt-shaped’ saddle patches as well, or none at all due to no others being photographed from this angle.

As each of the orca moved forward through the water a facet of the light created what appeared to be a pale grey ‘stripe’ extending across the base of their dorsal fin. Although the ‘stripe’ remained visible on the adult male (orca #5) in both Figs. 4, 5, it was narrower in the latter. Using examples from New Zealand (NZ), we provide images to illustrate how such a ‘stripe’ may (or may not) be perceptible under varying conditions, i.e., that it is likely to manifest as a ‘trick-of-light’ (Figs. 8–11). Schematic drawings (Figs. 12–15) compares the generalised and typical saddle patch positions of orca, to the indistinct and atypical ‘belt’ shape documented on the Fiji 2006 orca, as well as the ‘trick-of-light’ grey ‘stripe’.

## DISCUSSION

By using a standardised procedure to categorize records and to only classify those with imagery as *Confirmed*, we provide the first evidence of the species in Fijian waters. Our evidence was gathered through the Authors Databases and, in a manner similar to Visser & Fletcher (2023), via social media and other online platforms. Online imagery has been used to assess a range of aspects about environmental research (Ghermandi & Sinclair, 2019) including for animal distribution (Edwards et al., 2021), wildlife charisma (Willemen et al., 2015) and species determination (Daume & Galaz, 2016). It has been used specifically for orca when documenting new prey species (Visser & Fletcher, 2023; Visser et al., 2023) and potentially a new ecotype (Visser & Fletcher, 2023) – which may also be the case herein. We believe this is the first time that social media has been used to confirm the presence/range extension for *Orcinus orca*.

We do not believe that these sightings are extralimital records, as orca have been described from other tropical locations throughout the Pacific Ocean including in the eastern region, e.g., Ecuador (Alava et al., 2019), Galápagos Archipelago (Denkinger et al., 2020), Hawaiian Islands (Baird et al., 2006) and the western Pacific region, e.g.,





Figure 3. Two orca (either adult females or sub-adult males), from the group of five observed in 2006, who were photographed from slightly behind as they surfaced synchronously. Each exhibited the typical black dorsal surfaces but lacked a clearly defined saddle patch, although a very faint, slightly pigmented, opaque area with no clearly demarcated margins was present. This pigmentation appeared to extend downwards over the dorso-thorax in somewhat of a ‘belt’ shape. Note that from this angle there is no pale grey stripe across the base of the dorsal fin of either individual (compare to Figs. 4-7). Image available in jpg and processed with Adobe Photoshop and Topaz Photo AI. Photo © Gerald McCormack.



Figure 4. All five orca at the surface together. The numbers assigned were from left to right so individuals can be tracked through the sequence of three photos (taken less than 2 seconds apart) (Figs. 4-6). A range of the characteristics of the species are indicated in Table 2. Note that none of the five orca have a clearly defined, typical saddle patch. A pale grey ‘stripe’ or ‘band’ extending across the base of the dorsal fin on each of the animals is likely to be an artefact of the light. Orca #1 exhibits a typical white eye patch. Orca #2 has part of its head out of the water and the melon descending to the characteristic short, rounded rostrum is visible. This individual also has a series of small notches in the trailing edge of its dorsal fin, which becomes more visible as it moves forward (e.g., see Figs. 5, 6 and SM3). Orca #4 has a rectangular shaped notch out of the trailing edge of its dorsal fin (also see Fig. 7 and SM3). An adult male is distinguishable due to his large dorsal fin, i.e., Orca #5. Image available in RAW and processed with Adobe Lightroom and Topaz Photo AI. Photo © David Cothran.



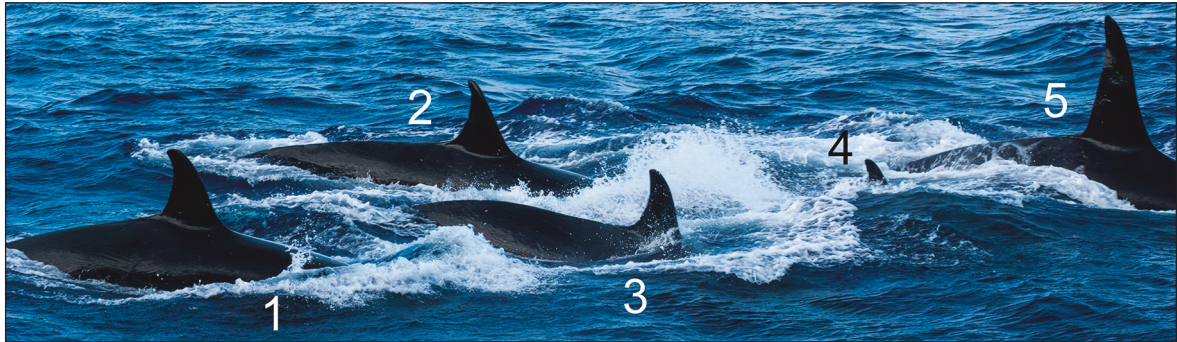


Figure 5. As the orca move through the water the pale grey stripe across the bottom of the dorsal fin of Orca #5 remains visible but it appears narrower as this individual moves forward. Image available in RAW and processed with Adobe Lightroom and Topaz Photo AI. Photo © David Cothran.

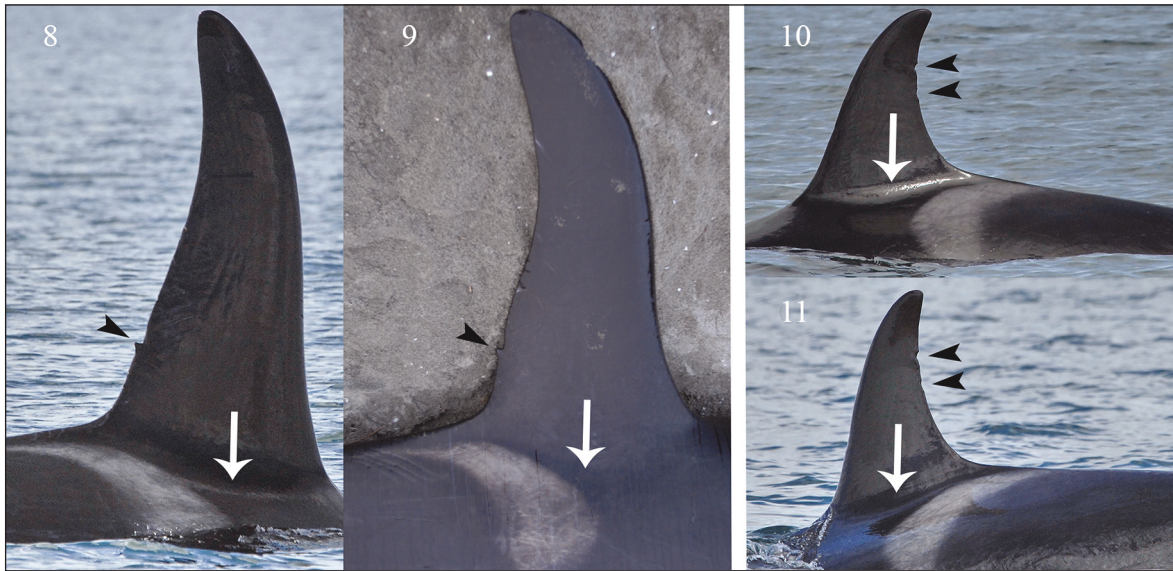


Figure 6. The saddle patch area and the caudal peduncle of Orca #1 and #2 are more exposed as they submerge. Orca #3 is nearly completely submerged. Image available in RAW and processed with Adobe Lightroom and Topaz Photo AI. Photo © David Cothran.

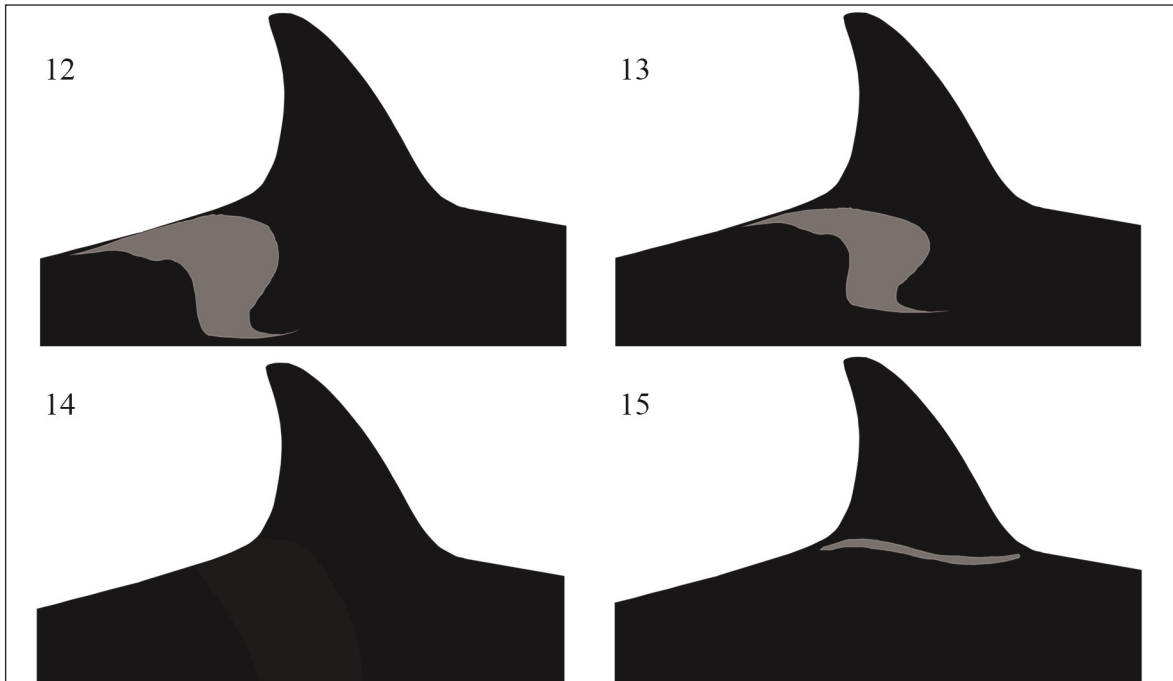


Figure 7. Taken from a similar angle to Figs 4-6, the chin and right mandible of Orca #3 (partially visible through the water) are both white and a small upper posterior section of the right white eye patch can also be seen on this same orca. Orca #4 has no clearly defined saddle patch, whilst a pale grey stripe across the bottom of the fin is visible, likely an artefact of the light. A rectangular shaped notch on the trailing edge of its dorsal fin is visible. Orca #5 has a white eye patch and the characteristic sexually dimorphic tall dorsal fin of an adult male orca. Image available in jpg and processed with Adobe Photoshop and Topaz Photo AI. Photo © Gerald McCormack.





Figures 8–11. Under certain light conditions a grey ‘stripe’ may (or may not) appear on photographs of orca. Photographing the same individual under different conditions illustrates that a grey ‘stripe’ is, in these instances, an artificial artefact of the light. Black arrowheads indicate notches on the dorsal fin of each orca which contribute to confirmation of each individual’s identification. White arrows indicate areas where a grey ‘stripe’ may (or may not) appear. An adult male NZ Coastal orca (NZ157) photographed alive in 2007 (Fig. 8) with a grey ‘stripe’, *cf* dead in 2010 (Fig. 9) with no ‘stripe’. An adult female NZ Coastal orca (NZ148) photographed on the same day in 2007, but at different angles; perpendicular (Fig. 10) with a grey ‘stripe’, and from slightly behind (Fig. 11) with no grey ‘stripe’. Images available in RAW and no software algorithms were applied Photographs © Ingrid N. Visser / Orca Research Trust.



Figures 12–15. Typical placement of the saddle patch pigmentation on an orca, either posterior to the dorsal fin (Fig. 12), or partially under the dorsal fin (Fig. 13), compared to the indistinct ‘belt’ shape on the Fijian orca (Fig. 14). If the grey ‘stripe’ (Fig. 15) is not an artefact of the light, it appears to extend across the base of the dorsal fin. Illustrations by Ingrid N. Visser.

New Caledonia (Noumea) (Garrigue & Greaves, 2001) and Naru (Miyazaki & Wada, 1978) and in Papua New Guinean waters (Visser & Bonoccorso, 2003) further to the west of Fiji. Furthermore, given these other records in tropical waters, we do not consider the Fiji records to be ‘out of habitat’, which has been defined as outside of what is normally regarded as its usual or typical habitat (Anonymous, 2021).

Despite this, we note that there was a scarcity of records. But the limited number of records may not be a true reflection of the low density of the species. Instead, they may rather be correlated to the difficulty of observing wide-ranging individuals in a country with extensive marine territory - approximately 1,290,000 km<sup>2</sup> which is nearly 70 times larger than its landmass, the latter being comprised of an archipelago of over 300 islands (Republic of Fiji, 2020). Alternatively (or additionally), the opportunistic nature of the data set may be a facet of a community with relatively limited access to social media through, not only affluence, but also physical infrastructure (Horst & Foster, 2024). We acknowledge that these constraints are not mutually exclusive. Conversely, the small number of records may be an actual indication of the low density of the species in the region. To support this, we found no records in platforms such as the photo-sharing website Flickr, nor from the biodiversity mapping and observations sharing application iNaturalist, despite these being two of the larger social media entities with photographs/citizen science data for wildlife (e.g., as of January 2023 the former has 112 million registered users and the latter 3.2 million – data sourced from each platform). Likewise, we found only three records (from the same encounter, i.e., one meta-record) on YouTube, with over 2.7 billion registered users. This low number of records may be telling, as the number of videos of shrikes (a group of birds which have a unique behaviour of impaling prey) on YouTube has been identified as having a strong correlation to the classical scientific literature (Dylewski et al., 2017) and by default, information about the species. It has also been suggested that this video online source may be an alternative repository of information for species living in the tropics and/or less studied regions (Dylewski et al., 2017). In a similar way to shrikes, orca are a ‘high-profile’

species, considered charismatic (Ross, 2006) and one of the most desirable cetacean species to observe in the wild (Duffus & Dearden, 1993) as well as one of the top two species drawcards to whale watchers around the world (Hoyt, 2001; Copello et al., 2021). Considering this interest in orca, along with the increased use of smartphones to disseminate sightings of the species (Visser & Fletcher, 2023), one would expect there to be an online presence that reflects their physical presence in a region. This, along with the possible re-sighting of one adult male nearly eight years and yet only 130 km away, apart suggests that the orca in this area are either part of a sparse local population or they return to Fijian waters periodically. Therefore, it is our conclusion that the small number of records is representative of a small population within Fijian waters.

Regardless, even with our very small dataset we were able to illustrate that the species has been observed across a substantial portion of the archipelago, albeit that the sightings are clustered around the main islands/groups in the northern waters. Furthermore, we gathered imagery on one group of orca which illustrated the atypical ‘belt’ of extremely faint pigmentation. This pigmentation and lack of a saddle patch was not represented on any other orca documented in Fijian waters (notwithstanding that again only limited images were available to review). Moreover, we could find no historic or contemporary literature or illustrations, nor images in any orca photo-identification catalogues, which described or illustrated a ‘belt’ pigmentation in the area where the saddle patch is normally found. We have ruled out that these Fiji orca were melanistic, as individuals in the group were documented with white eye patches, mandibles and chins. Although melanistic orca have been documented before, all records that we could discover were from the Northern Hemisphere and in temperate to cold waters (Scammon, 1874; Scheffer & Slipp, 1948; Sokolov, 1976; Visser et al., 2004). In comparison, even leucistic orca tend to exhibit saddle patches (e.g., see the example illustrated in Renner & Bell, 2008), so the absence of typical saddle patches on the orca from Fijian waters is an anomaly that warrants further investigation.

Evans & Yablokov (1978) stated that paler pigmentation “*is observed at the rear and side of the*



dorsal fin of all living killer whales **without exception.**” [our emphasis added]. However, their research did not encompass populations found in tropical waters. Although the research on tropical populations of orca is still relatively limited, a number of authors have recently noted fainter than typical saddle patches on individuals and entire groups (e.g., Baird et al., 2006; Olson & Gerrodette, 2008; Vargas-Bravo et al., 2020; Mäkeläinen et al., 2024). Still, not all orca in tropical waters have faint saddle patches (e.g., Visser & Bonaccorso, 2003; Bolaños-Jiménez et al., in press and see our SM3).

A number of authors have proposed that pigmentation, including saddle patch shape, could be important for discerning various orca groups at population level (Evans & Yablokov, 1978; Evans et al., 1982; Sugarman, 1984). Evans & Yablokov (1978) stated that “*computation of [the saddle patch] shape is of considerable importance from a population viewpoint.*” Baird & Stacey (1988) suggested that “*As the saddle patch shape may be heritable to a large degree, these differences suggest genetic isolation of the populations. If so, this technique may be used to delineate stocks of killer whales from other areas*”. Following on from this early work, we recommend that field studies be conducted in Fijian waters to search for the orca described herein, and other individuals of this population, to gather further details about their pigmentation as well as other aspects of their biology.

As pointed out by various authors (e.g., McClellan et al., 2014; García-Barón et al., 2020; Visser & Cooper, 2020), marine megafauna serve as crucial reminders of our essential roles in how we can target our conservation efforts to preserve biodiversity. Management authorities require robust information to create recovery or conservation plans and understanding variations, such ecotypes within the *Orcinus orca* species complex are part of the ‘big picture’ for these animals (Whale and Dolphin Conservation Society et al., 2002; Mäkeläinen et al., 2024). In the case of the Fijian orca with extremely indistinct saddle patches, this variation may indicate that this group is either a uniquely pigmented group or an entirely new, and as yet undescribed, ecotype of orca. Either way, they warrant dedicated research to better understand and protect them.

## ACKNOWLEDGEMENTS

The Orca Research Trust thanks dodoland (Orca EUGY), Yamaha Motors, Marine North Limited and Uber Ultrafast Broadband for their on-going support over many years. Ingrid Visser extends her gratitude to her Patreon supporters for their financial assistance during the preparation of this publication and she extends a special thanks to the Avatar Alliance Foundation and OceanX for their philanthropic support of her work and that of the Orca Research Trust, through the Global Orca Charity. Thanks to Scout Trom for her assistance with extracting screen grabs from the videos. Thank you to all those who contributed their original photographs, video and data, including: Kesa Bill, Emmanuel German Markham, James May, Colleen O’Neill and Paddy Todd. Courtney Vail provided valuable input as a reviewer and we thank her for her time.

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Visser et al. (2024) First confirmed records of Fijian orca (*Orcinus orca*, Linnaeus, 1758).

### SUPPLEMENTAL MATERIAL SM1 – Details of records of orca (*Orcinus orca*, Linnaeus, 1758) in Fijian waters.

All records, including duplicates are listed here. Duplicates (indicated by ‘a’, ‘b’ etc) are conflated to create meta-records. Text in bold indicates key words to describe location or other aspects regarding the animals. Text in red bold indicates key words used to determine status. Text in [square brackets] is subsequent citation of this specific reference where the details have changed.

Record #	DATE YYYYMMDD	LOCATION	Record Category (Published / Other media)	Record Type	# of ORCA	PHOTOS OR VIDEO	SOURCE & DETAILS of SIGHTING
1a	1994	near Suva, Fiji	Published	Presumed	5-8	NO	<p><i>Anonymous. (1995). Meanwhile, killer whales make rare appearance. Pages 45 Pacific Magazine. Pacific Magazine Corporation, Honolulu, Hawai'i, USA.</i></p> <p>whole article reads:            "Killer whales, often referred to as "orcas" have been spotted in Fiji waters near <b>Suva</b>.            Killer whales are rare in tropical seas, but schools of them <b>were seen</b> by anglers taking part in the Fiji International Billfish Tournament late <b>last year</b>. Albert Threadingham, tournament director, said it in the first time in memory that orcas have been sighted in the area.            An angler from Hawaii, David Nottage, said he saw schools of <b>between five and eight of the whales and estimated their lengths at between 8 and 10 meters (26 to 33 ft)</b>. Orcas are easy to distinguish from other sea creatures by their distinctive markings.            Scientifically, they are a type of fierce large dolphin that hunts in packs, preying on large fish, seals and whales.            Radio Australia"</p> <p>[subsequently cited in Miller (2023), page 65 in non-numbered table, lists orca as '<b>unconfirmed species</b>' (Anonymous 1995)]</p>

Visser et al. (2024) First confirmed records of Fijian orca (*Orcinus orca*, Linnaeus, 1758).

Record #	DATE YYYYMMDD	LOCATION	Record Category (Published / Other media)	Record Type	# of ORCA	PHOTOS OR VIDEO	SOURCE & DETAILS of SIGHTING
							<p>Reeves, R. R., Leatherwood, S., Stone, G. S. &amp; Eldredge, L. G. (1999). <i>Marine mammals in the area served by the South Pacific Regional Environment Programme (SPREP). South Pacific Regional Environment Programme and United Nations Environment Programme, PO Box 240, Apia, Samoa. 48 pp.</i></p> <p>NOTE: Reeves et al. (1999) is a secondary citation of Anonymous (1995)</p>
1b	1994	Fiji	Published	Presumed	~	NO	<p>page 12</p> <p>"<b>a small pod (5-8 individuals)</b> was <b>reportedly seen</b> during the Fiji International Billfish Tournament in <b>1994</b> (Anonymous, 1995a)"</p> <p>[Reeves et al (1999) is a secondary citation of Anon (1995) ] cited in Miller (2006) as ""Reeves et al. (1999) indicated <b>anecdotal reports</b> of... orca"</p> <p>[Reeves et al. (1999) is a secondary citation of Anon (1995) ] cited in Miller et al (2016) as "A previous record cited <b>the presence of</b> killer whales in Fijian waters; however, details and corroborating evidence were limited (Reeves et al., 1999)." <i>Miller (2006) Current State of Knowledge of Cetacean Threats, Diversity and Habitats in the Pacific Islands Region</i></p>
1c	1994	near Suva, Fiji	Published	Presumed	~	NO	<p>page 30</p> <p>"Reeves et al. (1999) indicated <b>anecdotal reports</b> of ... orca"</p> <p>[NOTE: This is a <b>plural</b> reference, and also NOTE that Reeves et al. (1999) record cites Anonymous (1995), i.e., this is a duplicate 'record' of the instance cited in the Table on the following page]</p> <p>page 31</p> <p>Table "<b>Unconfirmed</b> Species" lists "Orcinus orca, Orca (Anonymous, 1995)"</p>

Visser et al. (2024) First confirmed records of Fijian orca (*Orcinus orca*, Linnaeus, 1758).

Record #	DATE YYYYMMDD	LOCATION	Record Category (Published / Other media)	Record Type	# of ORCA	PHOTOS OR VIDEO	SOURCE & DETAILS of SIGHTING
1d	Pre 2009	'Fiji'	Published	Presumed	~	NO	<p>Miller (2009). <i>Current State of Knowledge of Cetacean Threats, Diversity and Status in the Pacific Islands Region (Revised 2009) - UNEP/CMS/PIC2/Inf.6-01. Second Meeting of the Signatories for the Convention of Migratory Species Memorandum of Understanding for the Conservation of Cetaceans and their habitats in the Pacific Islands Region. July 28-29th 2009, Auckland, New Zealand.</i></p> <p>page 32</p> <p>"Reeves et al. (1999) indicated <b>anecdotal reports</b> of .... orca..."</p> <p>NOTE: This is a plural reference, and also NOTE that Reeves et al. (1999) record cites Anonymous (1995), i.e., this is a duplicate 'record' of the instance cited in the Table on the following page]</p> <p>page 33</p> <p>Table Records of Cetaceans in the Waters of Fiji "<b>Unconfirmed Species</b>" lists "Orcinus orca, Orca (Anonymous 1995)"</p>
1e	not stated	Fiji	Published	Presumed	~	NO	<p>Miller, C. and S. Tikoca (2010). <i>Cetacean biodiversity of the Fiji Islands. Volume 2: Marine resources inventory of the Fiji Islands. Natural resource inventory report of the Fiji Islands 2010 B. C. Prasad. Suva, Fiji, University of the South Pacific: Appendix: 59-62</i></p> <p>page 60-61</p> <p>"Additional <b>species sighted</b> in Fijian waters include ....., orca, .... (Gibbs &amp; Paton 2003 in Bourke &amp; Powell, 2004; Reeves et al. 1999; Miller, 2009)."</p> <p>NOTE: It is unclear which reference is the source for the orca sighting page 60 Table 1: Summary of cetacean <b>species reported</b> in Fijian waters. <i>Orcinus orca</i> Killer whale"</p>

Visser et al. (2024) First confirmed records of Fijian orca (*Orcinus orca*, Linnaeus, 1758).

Record #	DATE YYYYMMDD	LOCATION	Record Category (Published / Other media)	Record Type	# of ORCA	PHOTOS OR VIDEO	SOURCE & DETAILS of SIGHTING
1f	Pre 2010	In Fijian waters	Published	Presumed	~	NO	<p><i>Prasad, B. C. (2010). Volume 2: Marine resources inventory of the Fiji Islands. Natural resource inventory report of the Fiji Islands 2010. Suva, Fiji, University of the South Pacific: 94.</i></p> <p>NOTE: This Prasad (2010) reference is the whole book, BUT it also has a brief section on cetaceans (other than the Miller &amp; Tikoca (2010) section), which has identical text to Miller &amp; Tikoca (2010).</p> <p>page 18            "Additional <b>species sighted in Fijian waters</b> include .... <b>orca</b>, .... (Gibbs &amp; Paton 2003 in Bourke &amp; Powell, 2004; Reeves et al. 1999; Miller, 2009)."</p> <p>page 19            "Table 2.4 Summary of Cetacean Species <b>Reported in Fijian Waters</b>" - lists <b>orca</b> (no other details)            Table is cited as "Source: Created by Tikoca &amp; Skelton, (2010)."            However, no reference is listed for this and it appears to be that the two authors who contributed to the whole volume, Siteri Tikoca and Posa Skelton, compiled this table (and others throughout the volume) specifically for the required sections, as the year is the same as this publication.</p>



Visser et al. (2024) First confirmed records of Fijian orca (*Orcinus orca*, Linnaeus, 1758).

Record #	DATE YYYYMMDD	LOCATION	Record Category (Published / Other media)	Record Type	# of ORCA	PHOTOS OR VIDEO	SOURCE & DETAILS of SIGHTING
1g	Pre 2016	Within Fijian waters In Fijian waters Waters surrounding Tuvana Island, Lau group	Published	Presumed	~	NO	<p>Miller, C., et al. (2016). "Cetacean diversity, common occurrence and community importance in Fijian waters. <i>Pacific Conservation Biology</i>." <i>Pacific Conservation Biology</i> 22(3): 272-280.</p> <p>page 275 Table 2. Listing of '<b>confirmed</b>' cetaceans species <b>within Fijian waters</b> Common name, Killer whale; Scientific name, <i>Orcinus orca</i> References J. Smith, 2010 (pers. comm.)"</p> <p>page 276 "A previous record cited the <b>presence</b> of killer whales <b>in Fijian waters</b>; however, details and corroborating evidence were limited (Reeves et al. 1999)". [NOTE that the Reeves et al. (1999) record cites Anonymous (1995), i.e., Reeves et al (1999) is a secondary source, not the original]</p> <p>page 276 "<b>Opportunistic yet well documented visual records</b> were available for .... <b>killer whale</b> (<i>Orcinus orca</i>) (J. Smith, pers. comm., 2010)"</p> <p>page 278 Table 4. A preliminary listing of <b>areas of common occurrence</b> and community importance for cetaceans <b>in Fijian waters</b> Location, <b>Waters surrounding Tuvana Island, Lau group</b> Cetacean species present, Killer whale; <b>Confirmed, N [No]</b></p>

Visser et al. (2024) First confirmed records of Fijian orca (*Orcinus orca*, Linnaeus, 1758).

Record #	DATE YYYYMMDD	LOCATION	Record Category (Published / Other media)	Record Type	# of ORCA	PHOTOS OR VIDEO	SOURCE & DETAILS of SIGHTING
1h	1994	near Suva, Fiji	Published	Presumed	~	NO	<p>Miller (2023). <i>Review of cetacean diversity, status and threats in the Pacific Islands region 2021</i>. Secretariat of the Pacific Regional Environment Programme, Apia, Samoa. 87 pp.</p> <p>page 64-65</p> <p>Appendix Table (not numbered), titled "Records of Cetaceans in the Waters of Fiji" lists orca in the "<b>unconfirmed</b>" section and cites (Anonymous, 1995).</p> <p>NOTE, the way this is entered into the table, it appears that no other sightings have occurred in Fiji but we already know this is incorrect due to the Miller et al. (2016) publication (with the 2010 pers. com.) and the 2020 sightings reported in the Fiji Times (keeping in mind that this Miller publication is from 2023).</p> <p><i>Kesa (Sunny) Bill pers. comm. to authors.</i></p>
2	2002	Savusavu Bay, Fiji	Other Media	Unconfirmed	~	NO	<p>"in 2002 travelling from Bua to Savusavu <b>crossing Savusavu Bay</b> you may recalled [sic] 2002 was before smartphones and camera were introduce [sic]".</p> <p><i>David Cothran, Gerald McCormack.</i></p>
3a	20060914	south-west coast of Viti Levu, Fiji, 18° 02' S, 177° 11' E	Authors Observation/ database	Confirmed	5	YES PHOTOS	<p>See this publication.</p>
3b	20060914	Fiji	Published	Confirmed	5	YES PHOTOS	<p><i>Dwyer, S. L. and I. N. Visser (2011). "Cookie cutter shark (Isistius sp.) bites on cetaceans, with particular reference to killer whales (orca) (Orcinus orca)." Aquatic Mammals 37(2): 111-138.</i></p> <p>page 128</p> <p>"no images of orca from ... <b>Fiji</b>, .... showed bite marks (Visser, unpub. data)." <i>Mäkeläinen, P. H., Visser, I. N., Cooper, T. E. &amp; Cusson, M. 2024. Worldwide variation in shape and size of orca (Orcinus orca) saddle patches. Marine Mammal Science, 41(1), e13171 (13171-13118).</i></p> <p><a href="https://doi.org/10.1111/mms.13171">https://doi.org/10.1111/mms.13171</a></p>
3c	20060914	Fiji	Published	Confirmed	5	YES PHOTOS	<p><i>Mäkeläinen, P. H., Visser, I. N., Cooper, T. E. &amp; Cusson, M. 2024. Worldwide variation in shape and size of orca (Orcinus orca) saddle patches. Marine Mammal Science, 41(1), e13171 (13171-13118).</i></p> <p><a href="https://doi.org/10.1111/mms.13171">https://doi.org/10.1111/mms.13171</a></p>

Visser et al. (2024) First confirmed records of Fijian orca (*Orcinus orca*, Linnaeus, 1758).

Record #	DATE YYYYMMDD	LOCATION	Record Category (Published / Other media)	Record Type	# of ORCA	PHOTOS OR VIDEO	SOURCE & DETAILS of SIGHTING
							<p>page 11</p> <p>"All saddle patches in the Republic of <b>Fiji geographic group</b> belonged to the Other category as there were either no saddle patch shapes or they were indefinable."</p> <p><i>Miller, C., Batibasaga, A., Chand, P., Dulunaqio, S., Fox, M., Jupiter, S., Naisilsisili, W., Nand, Y., Sharma-Grounder, S. &amp; Smith, B. D. (2016). Cetacean diversity, common occurrence and community importance in Fijian waters. Pacific Conservation Biology, 22(3), 272-280.</i></p>
4a	Pre 2016	<p>within Fijian waters</p> <p>in Fijian waters</p> <p>Waters surrounding Tuvana Island, Lau group</p>					<p>page 275</p> <p>Table 2. Listing of '<b>confirmed</b>' cetacean species <b>within Fijian waters</b> Common name, Killer whale; Scientific name, <i>Orcinus orca</i> References, J. Smith 2010 (pers. comm.)"</p> <p>page 276</p> <p>"<b>Opportunistic yet well documented visual records</b> were available for .... killer whale (<i>Orcinus orca</i>) (J. Smith, pers. comm., 2010)"</p> <p>"A previous record cited the <b>presence</b> of killer whales <b>in Fijian waters</b>; however, details and corroborating evidence were limited (Reeves et al., 1999)".</p> <p>page 278</p> <p>Table 4. A preliminary listing of <b>areas of common occurrence</b> and community importance for cetaceans <b>in Fijian waters</b> Location, <b>Waters surrounding Tuvana Island, Lau group</b> Cetacean species <b>present</b>; Killer whale, <b>Confirmed, N [No]</b> <i>Qica, E. R. and S. Deo (2017). National Biodiversity Strategy and Action Plan 2017–2024. M. o. Environment. Suva, Fiji, Government of the Republic of Fiji: Pp80.</i></p>
4b	not stated but cites Miller (2016, which gives a pers. com. from 2010)	Fiji	Published	Confirmed	~	UNKNOWN	<p>page 18</p> <p>"2.7.3d Marine Mammals</p> <p>A review of recent and reliable records <b>confirmed</b> 10 cetacean species <b>in Fiji's waters</b> ... killer whale (<i>Orcinus orca</i>), ... (Miller et al., 2016)."</p>

Visser et al. (2024) First confirmed records of Fijian orca (*Orcinus orca*, Linnaeus, 1758).


Record #	DATE YYYYMMDD	LOCATION	Record Category (Published / Other media)	Record Type	# of ORCA	PHOTOS OR VIDEO	SOURCE & DETAILS of SIGHTING
5	20150816	18 27.748 S 178 25.184 E east of Beqa Island, Fiji	Other Media	Confirmed	3	YES VIDEO	<p><i>Paddy Todd, Facebook and pers. comm. to authors</i></p> <p>Orcas in <b>Fiji</b> - Sunday 16th Aug, 2015 - 0943 hrs - 18° 27.748 S 178° 25.184 E Fiji - we spotted a pod of inquisitive Orca <b>in Fiji waters</b> - Surface water temp = 26°C</p> <p>We were out fishing and they spotted us from a distance and headed over. About <b>6 or seven - various sizes - males - females - younger ones</b>. A couple of them played with our lures - picking it up on the top of his head and purposely tossing it aside." FaceBook post says "This one came right under the boat while another, just as big, came right up to the back ... We still had lures in the water as they just came at us ... One of them lifted a lure up on his/her nose and flicked it away ... There was also what looked like a new born swimming upside down for a while and getting herded away ... Farken brilliant!"</p>
6a	20200312	Tavenui, Fiji	Other Media	Confirmed	5	YES VIDEO	<p><i>Colleen O'Neill at Tavenui Palms Resort, Facebook and pers. comm. to authors.</i></p> <p>"We enjoyed a beautiful encounter with these majestic Orca whales. They spent time playing around the boat and were so friendly. " Original obtained from Colleen O'Neill at Tavenui Palms Resort.</p>
6b	20200507	Near Tavenui (Somosomo Strait)	Other Media	Confirmed	1	YES PHOTOS	<p><i>20200508 in Fiji Times</i></p> <p>Original image provided by Garden Island Resort</p>
6c	2020	Near Tavenui (Somosomo Strait)	Other Media	Confirmed	1	YES VIDEO	<p><i>Facebook posting dated 20200507 for Fiji One News</i></p> <p>Two thumbnails from two videos from this date appear to be the same videos supplied by Colleen O'Neill at Tavenui Palms Resort. The short accompanying text also gives that impress as one is "We enjoyed a beautiful encounter with these majestic Orca whales. They spent time playing around the boat and were so friendly. " The second comment (also from a video by Tavenui Palms Resort)</p>

Visser et al. (2024) First confirmed records of Fijian orca (*Orcinus orca*, Linnaeus, 1758).

Record #	DATE YYYYMMDD	LOCATION	Record Category (Published / Other media)	Record Type	# of ORCA	PHOTOS OR VIDEO	SOURCE & DETAILS of SIGHTING
							is "While enjoying this idyllic island with its world famous diving on the Raonbo Reef we encounter [sic] a pod of curious orca whales.
6d	2020	off Tavenui (Somosomo Strait)	Other Media	Confirmed	1	YES PHOTOS	<i>Fiji Times.com. Killer Whale Sighting</i> Original image taken by Tavenui Palms Resort & provided to Fiji Times.
7	pre 20200507	Kadavu, Fiji	Other Media	Unknown	~	NO	<i>Kesa Bill, pers. comm. to authors</i> Confirmed that there are no photos or video available <i>Jone Salele Uluiviti comment under Fiji Times Facebook</i>
8	pre 20200507	Wakaya Island, Fiji	Other Media	Unknown	~	UNKNO WN	"This is not the first sighting i have seen it [sic] closer to wakaya lighthouse twice". <i>Paddy Todd pers. comm. to authors</i>
9	20230710	18 09.304 S 178 45.342 E WNW of Nasilai, Fiji	Authors Observation/ database	Presumed	3	NO	Three - probably adolescent males (the 3 of them had the tall fins) heading west/north/west of Nasilai. They were very inquisitive and went right under the boat, alongside, behind and in front for about ½ hr. NOTE: Confirmed no photographs



Visser et al. (2024) First confirmed records of Fijian orca (*Orcinus orca*, Linnaeus, 1758).

Record #	DATE YYYYMMDD	LOCATION	Record Category (Published / Other media)	Record Type	# of ORCA	PHOTOS OR VIDEO	SOURCE & DETAILS of SIGHTING
10	20230722	"Fiji, around 10 miles south of the island Makogai"	Other Media	Confirmed	2 groups	YES VIDEO	<p><i>Niels Eikelboom &amp; Greetje Tops (Black Moon Sailing) Facebook posting and pers. comm. to authors</i></p> <p>"Speechless. First sailing trip [sic] through the islands of Fiji and already spoiled with orca's passing by. We spotted two pods with offspring in the distance, slowly but graciously. And finally an adult, probably a male, just in front of our bow!"</p> <p>"around 12.55 pm. Location: Fiji, around 10 miles south of the island Makogai"</p>
11a	20231227	Namotu Island, Fiji	Other Media	Confirmed	5	YES VIDEO	<p>Namotu Island "Orcas in Fiji! The things you see out on the water are incredible. This footage (and commentary) via our resident fishermen @e.markham &amp; @candrees. Such a rare sight, you guys are so lucky!"</p> <p> @e.markham"</p>
11b	20231227	Namotu Island, Fiji	Other Media	Confirmed	5	YES VIDEO	<p><i>Emmanuel German Markham on Instagram and pers. comm. to authors</i></p> <p>" we were around 4-7 miles in front of cast away channel."</p> <p>"We saw them jumping from a distance and then they passed near the boat and seemed to stay for around 15-20 minutes around the boat and they seem to have been feeding with the yellow fin tunas we were catching. They stayed near the same bait ball."</p>

Visser et al. (2024) First confirmed records of Fijian orca (*Orcinus orca*, Linnaeus, 1758).

Record #	DATE YYYYMMDD	LOCATION	Record Category (Published / Other media)	Record Type	# of ORCA	PHOTOS OR VIDEO	SOURCE & DETAILS of SIGHTING
12a	20240211	Fiji	Other Media	Confirmed	12	YES VIDEO	<p><i>“LibertyBliss_” Instagram account</i></p> <p>"one of those moments in your life where you just have to stop and take it all in, to say I'm feeling grateful would be an understatement 🌟 — we were making our way to a nearby Island to drop off our charter guests for their flight home, when we were approached by a pod of 12 killer whales. Amongst them were a couple of young calves showing off, learning all their skills from mum and having a whole lot of fun while doing so. These animals are just incredible! Big tick off the bucket list, that's for sure 🐳"</p> <p>NOTE: video taken from a high vantage point - perhaps off the bridge of a vessel?</p>
12b	20240211	Fiji	Other Media	Confirmed		YES VIDEO	<p><i>Tourism Fiji Instagram account</i></p> <p>Identical clip as “LibertyBliss_” (a reposting -with credit)</p>

**SUPPLEMENTAL MATERIAL SM2 –  
Inconsistencies, irregularities and  
anomalies in the Published records of orca  
(*Orcinus orca*, Linnaeus, 1758) in Fijian  
waters.**

Within the Published records for Fijian waters (see Supplemental Material S1 for the details of each record), there were inconsistent, irregular and anomalous ways in which authors described the sightings of orca (*Orcinus orca*, Linnaeus, 1758). We present some of these issues herein.

The first record from Fijian waters is by Anonymous (1995), who documented observations near Suva “*late last year*” (i.e. in 1994). That record is subsequently cited in ( $n=4$ ) publications (Reeves et al., 1999; Miller, 2006, 2009, 2023) (SM1). However, there were inconsistencies in reporting that single event or even how it, or subsequent citations, were interpreted. The original authors stated the orca “*were seen*”, for which Reeves et al. (1999) then described the species as “*reportedly seen ... (Anonymous, 1995)*”. Miller (2006) then stated that “*Reeves et al. (1999) indicated anecdotal reports [plural] of ..., orca, ...*”. Ten years later and still citing the Reeves et al. (1999) reference, Miller et al. (2016) elevated the existence of the species from ‘*anecdotal*’ to now stating “*A previous record [singular] cited the **presence** of killer whales in Fijian waters however, details and corroborating evidence were limited (Reeves et al. 1999)*” [our emphasis added].

Additionally, Miller (2006) and Miller (2009) not only cite that Anonymous (1995) record (as “*unconfirmed*”), but both the 2006 and 2009 publications also use identical text and add “*Reeves et al. (1999) indicated anecdotal reports of ... orca,...*” yet they fail

to identify that Reeves et al. (1999) is only a secondary source of the Anonymous (1995) record.

Other publications, such as Prasad (2010), and within the same volume Miller & Tikoca (2010), also list Reeves et al. (1999) as a source for the presence of orca in Fijian waters, whilst again not indicating that the Reeves et al. (1999) publication is a secondary source.

Miller & Tikoca (2010) we have noted already cite Anonymous (1995) and Reeves et al. (1999) but they also cited Miller (2009), as if it was an independent record, instead of a tertiary source.

Irrespective of the primary, secondary or tertiary citations, the sightings are described in various ways. For example *inter alia* the terms used were “*unconfirmed*” (Smith et al., 2010), “*anecdotal*” (Powell, 2003; Miller et al., 2016), as having a “*presence*” in Fijian waters (Miller et al., 2016), “*reportedly seen*” (Reeves et al., 1999), “*reported*” (Miller & Tikoca, 2010), “*confirmed*” (Mangubhai et al., 2019) and “*were seen*” (Anonymous, 1995) at times even when referencing the same record or its secondary source.

Descriptions within a single publication are also not always clear or consistent. For example, within Miller et al. (2016), the authors note that; “*Opportunistic yet well documented visual records were available for two additional species: killer whale (*Orcinus orca*) (J. Smith, pers. comm., 2010) and common minke whale (*B. acutorostrata*) (C. Miller, pers. obs., 2012–14)*. With this statement it is not clear if the reference to plural ‘records’ is for each species or across the two species, but regardless, one would logically presume that

‘visual’ means only sighted, whilst ‘documented’ implies there were photo and/or video and/or perhaps drawings or at least contemporaneous notes. However, no further details or evidence were provided to clarify this ambiguous statement.

Another layer of inconsistency was apparent when those same “*well documented visual records*” from J. Smith (2010) have been subsequently overlooked by Miller (2023) who only list the species in the “*unconfirmed*” section of a table for Fiji cetacean records (which has no table number, but can be found on their page 65) and provide the only source as Anonymous (1995). However, Miller (2023) does cite Miller (2016) elsewhere in that 2023 publication, but in reference to other species of cetaceans, just not orca. It is therefore unclear why the J. Smith (2010) records were omitted.

An example of an anomaly in the way the data is presented occurred when Miller et al. (2016) requires the reader to eliminate sources, as well as merge information, in order to ascertain relevant details for the records and then to draw contrasting conclusions as to the presence of orca in Fijian waters. To start with, the data appears straightforward, i.e., in their Table 2, which is titled “*Listing of ‘confirmed’ cetacean species within Fijian waters*” [our emphasis added] the authors have listed “*Killer whale Orcinus orca*”, with “(J. Smith, pers. comm., 2010)” as the source. Then, in their Table 4 which is titled “*A preliminary listing of areas of common occurrence and community importance for cetaceans in Fijian waters*” [our emphasis added], they again list the species as being found in Fijian waters under the column “*Cetacean species present*” where they include “*killer whale*”. And yet, in the next column titled “*Confirmed*”, they state

“*N*” (for no, i.e., **not** confirmed). This latter difference in status from Table 2, appears to be due to the authors self-imposed caveat for Table 4 of requiring “*more than 20 records in the past 10 years*” in order for the species to qualify for the status of ‘confirmed’. Despite failing to meet this criteria, the authors have then specifically listed the “*Waters surrounding Tuvana Island, Lau group*” as the location where orca were “*present*”.

In order to establish the source which provided the location from Miller et al. (2016) Table 4, the reader must first recognise that there must be ‘enough’ records that the species was documented sufficiently and frequently to warrant listing in a table of “*common occurrence*”, whilst also recognising that there is no definition of what constitutes ‘enough’. Next, the reader will recall that the Anonymous (1995) record was near Suva (see above, main text and SM1) and that Reeves et al. (1999) is just a secondary citation of Anonymous (1995). Therefore, one can confidently eliminate both of these publications as the source of the Miller et al. (2016) “*Waters surrounding Tuvana Island, Lau group*” location. This leaves the “*J. Smith, pers. comm 2010*” as the only source with mention of multiple records of the species (i.e., see Miller et al. (2016) Table 2 and page 276), as well as the only source for the location.

From there, the reader must then draw the conclusions that those J. Smith records were considered by Miller et al. (2016) to be (i) of high enough quality to have the species listed as “*confirmed*” in Fijian waters (their Table 2), but in direct conflict (ii) **not** “*confirmed*” (their Table 4). Nonetheless, Miller et al., (2016) considered those records sufficient for the species to be considered (iii) “*present*” for Table 4 and yet also (iv) seen

frequently enough, in a specific area, to warrant naming a “Location” (“Waters surrounding Tuvana Island, Lau group”) which is considered a site of “common occurrence” in their Table 4.

It is of note that the Miller et al. (2016) publication has been cited numerous times (e.g., Qica & Deo, 2017; Department of Environment Government of Fiji, 2020) in order to state that *Orcinus orca* is ‘confirmed’ in Fijian waters, despite there being no evidence provided as well as the irregularities and contractions noted above.

### Standardised System to Categorise records

To ensure that sightings of orca in Fijian waters are consistently reported, both historically and contemporaneously, we have used a standardised system to categorise records (see methods in main text body for full details).

Using that system, we would not classify the Anonymous (1999) record as *Confirmed*, based on the lack of imagery. However, we would classify it as *Presumed* based on the details which the original observer, David Nottage from Hawaii who had travelled to Fiji to compete in a Big-Game fishing tournament, provided to the Anonymous author. Mr Nottage gave a description of the physical size of the individuals, i.e., “between 8 and 10 meters (26 to 33 ft)”, which is consistent with the size for the species. Mr Nottage also stated there were “between five and eight” individuals. In tropical and temperate waters, although group sizes may be large, the mean size for orca was 5.3 (Dahlheim et al., 1982), which is also consistent with our findings for the average group size in Fijian waters (see Results in main text). In contrast cetacean species to

which an orca may be confused with - if seen from a great distance and no adult males were present - would be species such as short-finned pilot whales (*Globicephala macrorhynchus*, Gray, 1846) or false killer whales (*Pseudorca crassidens*, Owen, 1846), both of which are typically found in much larger groups (Jefferson et al., 2015). Furthermore, Mr Nottage was likely to have knowledge from observing marine life closely, based on our personal experience collaborating with Big-Game fishers and their observations of orca (e.g., see Visser, 2000 for some examples). As Anonymous (1995) stated, the species is “... easy to distinguish from other sea creatures by their distinctive markings”.

Likewise, we would not classify the records from J Smith, cited in Miller et al. (2016) as *Confirmed* as there was no imagery provided or referred to as evidence. But, taking into account the mention by Miller et al. (2016) of “well documented visual records”, we would instead classify them as *Presumed*.

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**SUPPLEMENTAL MATERIAL SM3 – Photos & screen grabs from videos of orca (*Orcinus orca*, Linnaeus, 1758) sighted in Fijian waters.**

Record numbers correspond to Table 2 and Fig. 1 in the main text and Supplemental Material SM1.

**Record #3. 20060914**

**South-west of Viti Levu**

**Photos.**

Source: David Cothran & Gerald McCormack as indicated.



**Fig. 3.1.** Orca #1, close up from Fig. 4 showing the black dorsal surfaces and the shape of the white eye patch. Photo © David Cothran.



**Fig. 3.2.** Orca #1, close up from Fig. 5 showing the black dorsal surfaces and no grey saddle patch. A small notch in the dorsal fin is indicated by the yellow arrowhead. Photo © David Cothran.



**Fig. 3.3.** Orca #2 close up from Fig. 5, showing the black dorsal surfaces and no grey saddle patch. Two notches in the dorsal fin are indicated by the yellow arrowheads. Photo © David Cothran.



**Fig. 3.4.** Orca #3 close up from Fig. 4, showing the black dorsal surfaces and no grey saddle patch. A notch near the base of the dorsal fin is indicated by the yellow arrowhead. Behind Orca #3 the rounded melon and short rostrum of Orca #2 are visible. Photo © David Cothran.



**Fig. 3.5.** Orca #4 close up from Fig. 4, showing the black dorsal surfaces and no grey saddle patch. A large rectangular notch near the top of the dorsal fin is indicated by the yellow arrowhead. Photo © David Cothran.





**Fig. 3.6.** Orca #5 close up from Fig. 5, showing the black dorsal surfaces and no grey saddle patch. The characteristic tall dorsal fin of an adult male orca is apparent . Photo © David Cothran.



**Fig. 3.7.** Orca #3, close up from Fig. 7, showing the black dorsal surfaces and the white right mandible and chin are visible through the water. The posterior upper area of the white eye patch is partially visible. Photo © Gerald McCormack.



**Fig. 3.8.** Orca #5 close up from Fig. 7, showing the black dorsal surfaces and the posterior of the white eye patch is partially visible. Photo © Gerald McCormack.

**Record #5. 20150816**  
**East of Beqa Island.**

**Video.**

Source: Paddy Todd (Lily G III).



**Fig. 5.1.** An orca approaches the back of the big-game fishing vessel. The black dorsal surfaces as well as the white eye patch and white chin are visible.

**Record #5. 20150816 continued**



**Fig. 5.2.** An underwater screen grab illustrates the grey saddle patches, black dorsal surfaces, white eye patch and white chin.



**Fig. 5.3.** The tall dorsal fin of an adult male is clearly visible as he approaches the back of the fishing vessel. The black dorsal surfaces as well as the white eye patch and white chin are also visible.



**Fig. 5.4.** One adult male had a large, rounded notch out of the trailing edge of his dorsal fin. A slightly paler saddle patch area is discernible. Although this is a *Low* quality screen capture (see main text for criteria for this classification), we include it here given the

distinct notch and the possibility of resighting this individual. See Fig. 10.1 & 10. 2 for a possible match on 20230726, 2901 days (7 years, 10 months and 11 days) between records.

**Record #6. 20200312  
Tavenui (Somosomo Strait).**

**Photographs, video.**

Source Colleen O'Neill (Tavenui Palms Resort)



**Fig. 6.1.** Three orca, including an adult male (right). The size of the other two suggests either an adult female or sub-adult male (left) and a juvenile (middle).



**Fig. 6. 2.** The comparative height of the dorsal fin on the adult male (right) is apparent.





**Fig. 6.3.** The black dorsal surfaces as well as the white flank patch on left side of the orca are clearly discernible. A saddle patch is possibly visible but is masked by the glare and reflection.



**Fig. 6.6.** The black dorsal surfaces as well as the white eye patch are visible. A grey saddle patch on this same individual is better seen in Fig. 6.7.



**Fig. 6.4.** The black dorsal surfaces and paler grey saddle patches are visible. On the animal's right flank, just posterior to the saddle patch is an oval scar, similar to those documented on orca which have been bitten by cookie cutter sharks (see Dwyer & Visser 2011 for examples).



**Fig. 6.7.** The black dorsal surfaces and the grey saddle patch visible – this is the same animal as in Fig. 6.6.



**Fig. 6.5.** The black dorsal surfaces as well as the white chin and thorax, as well as the rounded pectoral fins are visible.



**Fig. 6.8.** The black dorsal surfaces as well as the white eye patch and part of the white chin and the left flank patch are visible. A grey saddle patch is clearly visible.



**Record #10. 20230722**

**10 miles South of Makogai Island, Fiji**

**Video.**

Source “Sailing Black Moon”, Niels Eikenboom & Greetje Tops



**Fig. 10.1.** The black dorsal surfaces and white eye patch are visible. The tall dorsal fin characteristic of an adult male is prominent. A slightly paler grey saddle patch area is discernible.



**Fig. 10.2.** Although this is a *Low* quality screen capture (see main text for criteria for this classification), we include it here given what appears to be a large rounded notch in the trailing edge of the dorsal fin and see Fig. 5.4 for a possible match on 20150816, i.e., 2,901 days (7 years, 10 months and 11 days) between records. Note also the grey saddle patch. The white spots on the front of the dorsal fin are due to reflections.

**Record #11. 20231228**

**Namotu Island**

**Video.**

Source “Namotu Island”, Emmanuel German Markham.



**Fig. 11.1.** The black dorsal surfaces, white eye patch and white chin are visible on the closest of two orca (the second dorsal fin is visible behind the first orca).



**Fig. 11.2.** The black dorsal surfaces and white eye patch are visible on the two closest orca. Four of the five orca observed are together in this image.



**Fig. 11.3.** The black dorsal surfaces, white eye patch and white chin are visible on the closest orca as well as the rounded rostrum. Although partially obscured due to the blow from this orca, the grey saddle patches on the two orca behind it are also visible.



**Fig. 11.4.** The black dorsal surfaces and the grey saddle patches are visible on these three orca.



**Fig. 11.5.** The black dorsal surfaces and white eye patch and the rounded rostrum are visible on the furthest orca. A grey saddle patch is visible on the closest orca.



**Fig. 11.6.** Although this is a *Low* quality screen capture (see main text for criteria for this classification), we include it here as it shows the head of the adult male. The black dorsal surfaces, white eye patch and white chin as well as the rounded rostrum are visible.



**Fig. 11.7.** Although this is a *Low* quality screen capture (see main text for criteria for this classification), we include it here given what appears to be two notches in the trailing edge of the dorsal fin which may allow for possible matches.

**Record #12. 20240211**

**Fiji**

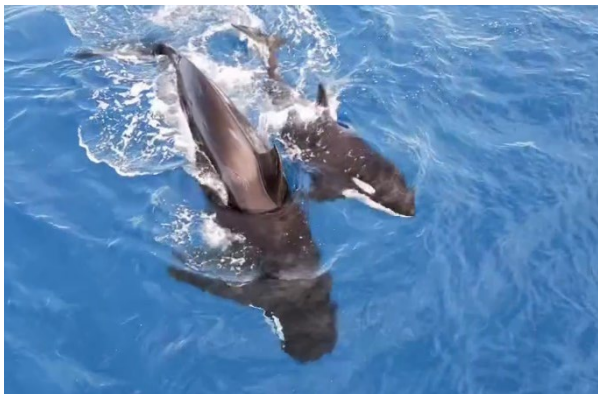
**Video.**

Source “LibertyBliss”

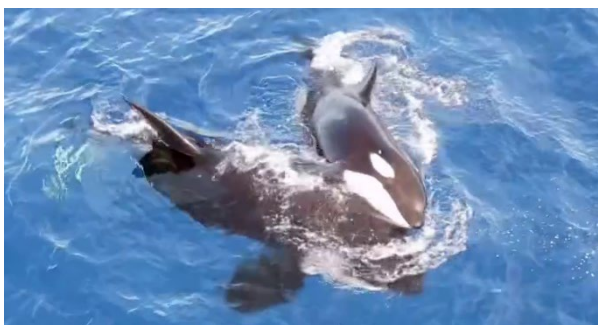


**Fig. 12.1.** A presumed adult female and a younger orca. The black dorsal surfaces and white eye patches are visible. Additionally, the grey saddle patch, white chin and white flank patch is visible on the younger orca.

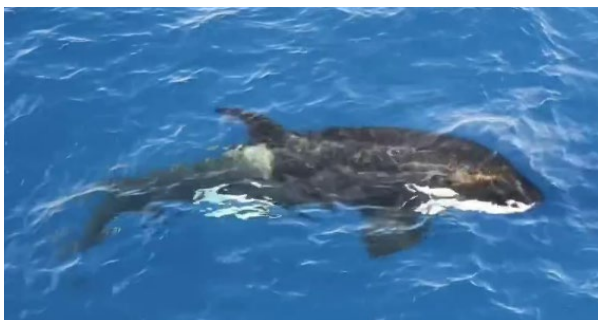
**Record #12. 20240211 continued**



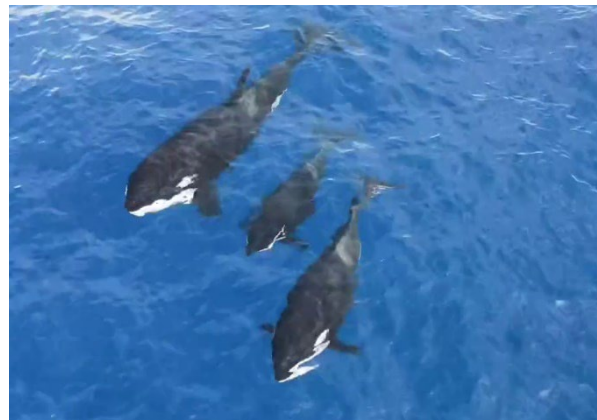
**Fig. 12.2.** The black dorsal surfaces and white eye patches are visible on both the adult and younger orca. Additionally, the grey saddle patch is visible on the presumed adult female and a white eye patch.



**Fig. 12.3.** The black dorsal surfaces and white chin, are visible on both individuals. The eye patch is visible on the younger orca, whilst the rounded pectoral fin is visible on the presumed adult female and her white chin is partially visible through the water surface.



**Fig. 12.4.** A third orca, with the black dorsal surfaces, white eye patch and chin, grey saddle patch and rounded pectoral fins are visible.



**Fig. 12.5.** Three orca, each illustrating the species characteristic black dorsal surfaces, white eye patch and chin, grey saddle patch and rounded pectoral fins.

**Acknowledgements**

In addition to the acknowledgements in the main body of the manuscript, we wish to extend our thanks to Emmanuel German Markham (Namotu Island), Colleen O'Neill (Tavenui Palms) and Paddy Todd (Lily G III), Niels Eikelboom & Greetje Tops (Sailing Black Moon) for their willingness to share their encounters and for providing the original footage for us to assess. They are citizen scientists in the purest form. Thank you also to 'Naumotu Island' & Carlos Andres, and 'Liberty Bliss' who posted their videos online.