Review of dugong detections in images collected during an imagery survey conducted in New Caledonia

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1 BACKGROUND AND OBJECTIVES

This study falls under a JCU-led project which retrospectively investigated various occupied aerial imagery approaches to survey dugongs (*Dugong dugon*) in the wild. Multiple occupied aerial surveys of dugongs have now been performed, all using different survey protocols and camera settings. Conducting a systematic review of how these surveys have performed can help the design of future imagery surveys in determining what camera settings worked best, under what survey regime and weather condition (i.e. time of day/ambient light, glare, seastate, water visibility).

Here we were interested to assess the overall image quality and dugong detectability as a function of survey design, imagery system and settings, and environmental conditions across a range of occupied imagery surveys. As a side investigation and in exchange of the sharing of data, we offered to conduct a comparative manual review of a subset of images collected in New Caledonia to inform managers on the veracity of the results obtained in their latest dugong population surveys (Duclos et al. 2018).

2 METHODS

We retrieved aerial images collected from three different occupied imagery surveys and during which dugongs were sighted (see details of each survey in Table 1): dugong trial surveys conducted in Shark Bay and Broome (Hodgson et al. Unpublished), a dolphin survey conducted in the Exmouth Gulf (Raudino et al. 2022), and a dugong population survey conducted around the main island of the New Caledonia archipelago (Duclos et al. 2018). Each of these occupied imagery surveys were conducted under different survey designs and protocols (e.g., aircraft type, flight speed, survey altitude), as well as different camera settings (e.g., type and number of cameras, attachment designs, camera angles, focal length, image capture settings) and image capture settings (e.g., shutter speed, aperture value, ISO sensitivity). As a preliminary assessment we wanted to conduct a rapid and subjective visual assessment of overall image quality and dugong detectability across the different datasets in our possession (**objective 1**).

A total of 555 images (n=125 images from Shark Bay/Broome, n=149 from Exmouth Gulf, n=281 from New Caledonia, were reviewed by two trained image reviewers using the Dugong Detector software (DD). Dugong sightings were verified and validated by the project lead (Cleguer). All potential dugong sightings were labelled manually using the WISDAM software (Wildlife Imagery Survey – Detection and Mapping; in development), and for each labelled feature/animal the following information was manually entered:

- The dugong is a single adult, a mum (as part of a mum-calf pair visible in the photo), a calf (as part of a mum-calf pair visible in the photo)
- The dugong is at the surface or submerged (split into mid-water or bottom)
- Level of certainty of the sighting (certain or uncertain)
- Image quality (good or poor), based solely on visual assessment of image crispness

Dugong sightings made on the New Caledonia image database were then compared to the sightings made by Duclos et al. (2018), (**objective 2**).

***TABLE 1**. DETAILS OF THE SURVEY AIRCRAFT, DESIGN AND CAMERA SETTINGS FROM THREE DIFFERENT OCCUPIED IMAGERY SURVEYS USED FOR OUR IMAGE ASSESSMENT.*

Item	Dataset 1: Dugong aerial survey in New Caledonia	Dataset 2: Dolphin survey in Exmouth, WA.	Dataset 3: Dugong survey trials in Shark Bay, WA	Dataset 3: Dugong survey trial in Kimberley, WA
Reference	Duclos et al. (2018)	Raudino et al. (2022)	Hodgson et al (Unpublished)	Hodgson et al (Unpublished)
Aircraft type/model	Cessna 206	Partenavia 68B high-wing aircraft	CASA-212	CASA-212
Onboard crew (pilot, engineer, observers)	Pilot, camera engineer	Pilot, survey team leader, 4 observers (2 on each side of plane)	Pilot, survey team leader, 4 observers (2 on each side of plane)	Pilot, survey team leader, 4 observers (2 on each side of plane)
Survey altitude(s) (in feet, ASL)	426 m (1400 ft) and 853 m (2800 ft)	152 m (500 ft)	152 m (500 ft) - 274 m (900 ft)	274 m (900 ft)
On-transect flight ground speed	90 knots	100 knots	110 knots	110 knots
Camera attachment setting	Belly mounted	Attachment underneath starboard wind	Belly mounted (behind Perspex window)	Belly mounted (behind Perspex window)
Number of cameras used (brand and model)	One, (Phase-One, IXU)	Three, (Canon, EOS 5DS R)	One (Nikon D200)	One (Nikon D200)
Megapixels	80	50.6 (36 × 24 mm CMOS sensor)	10	10
Camera angle	Nadir (90°)	Middle camera set nadir (90°), side cameras set at 30°	Nadir (90°)	Nadir (90°)
Focal length	55 mm at 1400 ft, 110 mm at 2800 ft	50 mm on nadir camera, 85 mm on side cameras	35 mm	35 mm
Image size (pixels)	10328*7760	8688*5792	3872*2592	3872*2592
Image footprint on water surface (width*height in m)	417 m (w)*313 m (h)	cumulative image swath of 279 m (w)	102 m (w) x 69 m (h) @ 153 m altitude; 185 (m) x 124 m (h) @ 274 m altitude	185 (m) x 124 m (h)
Theoretical GSD	4cm/pixel	0.76 - 1.25 cm/pixel	2.6 and 4.8 cm	4.8 cm
Total number of images collected during survey / Number of images including dugongs (after research group review)	19,986 | 149	413,000 | 281	Unknown | 92	Unknown | 33
Image format	Raw IIQ format, JPEG	JPEG	JPEG	JPEG

3 RESULTS

3.1 VISUAL ASSESSMENT OF OVERALL IMAGE QUALITY AND DUGONG DETECTABILITY

- Eighty one percent of images that included dugongs were rated as 'Good' quality.
- The New Caledonia dataset had the lowest level of dugong detection certainty (Figure 1).
- The dataset with the highest proportion of 'poor' quality images was the dataset from New Caledonia (37% of images) followed by the Shark Bay/Kimberley datasets (23%) and the Exmouth Gulf dataset (13%).
- The images from the Exmouth Gulf dataset had the lowest GSD values (average < 1.25 cm/pixel across the image swath) and visually appeared to be of the best quality. The footprints of these images were also much smaller than the images from the New Caledonia dataset.
- In the Raudino et al. (2022) study the Port and Starboard cameras were set at an angle of 30° for a survey altitude of 500 ft (Table 1). In ninety percent of the n = 28 images captured from the starboard camera, n= 61 images captured from the nadir camera and n = 54 images captured from the Port camera we could not to visually detect any difference created by camera angle on our ability to see through the water column at any location in the image (except due to changes in the environmental conditions across the image) nor to detect dugongs present in the image. We further investigated the remaining 10% of the images for which angle in the image was obvious and prevented us from seeing through the water column at all locations in the image and found that these were all taken when the aircraft circling to count dolphins.
- In the dataset coming from the New Caledonian surveys, the dugongs positioned underwater yet in favourable environmental conditions (clear shallow water, no glare, low sea state) were very small in size and the outline of their body shape was blurred indicating possible sub-optimum camera or image capture settings.

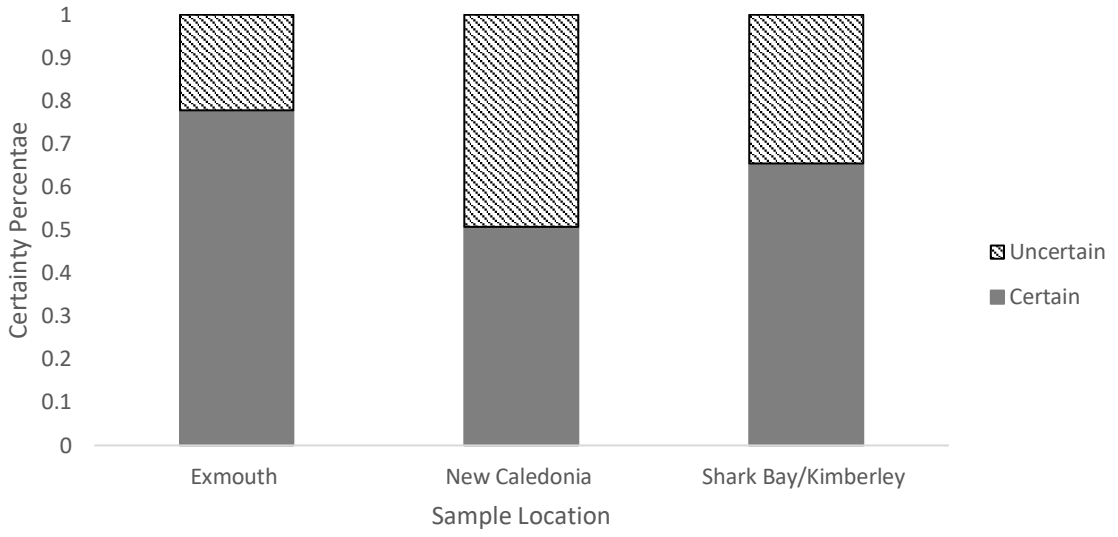

FIGURE 1. *PERCENTAGE OF CERTAINTY ACROSS EACH SAMPLE LOCATION. NOTE: SHARK BAY AND KIMBERLEY WERE GROUP DUE TO THE LACK OF DATA FOR EACH SUB-DATASET.*

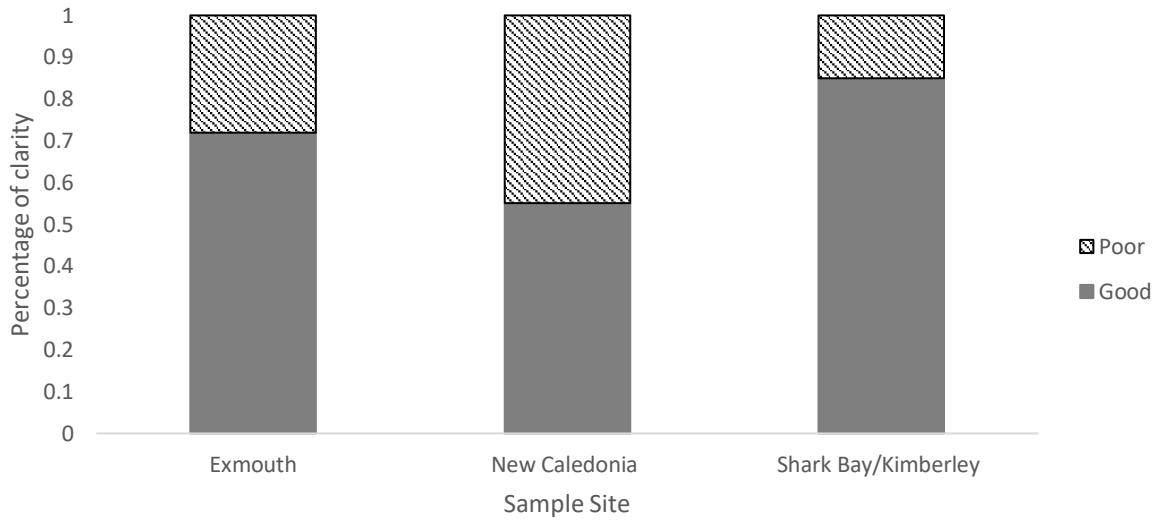

FIGURE 2. *PERCENTAGE OF "GOOD" AND "POOR" QUALITY PHOTOS FOR EACH SAMPLE LOCATION. NOTE: SHARK BAY AND KIMBERLEY WERE GROUPED DUE TO THE LACK OF DATA FOR EACH SUB-DATASET.*

3.2 COMPARISON OF MANUAL DETECTIONS IN THE NEW CALEDONIA IMAGE DATASET

- All results are presented in Table 1 and details of detections in Appendix table A.1.
- We retrieved 281 images from New Caledonia. Contrastingly, Duclos et al. (2018) reviewed a subset of 285 images (see "Tableau 3" in Duclos et al. 2018).
- We detected dugongs in 52 of the 281 reviewed images. In comparison Duclos et al. 2018 considered the 285 image to have potential dugong detections.
- We detected 101 animals (minimum number of animal in an image = 1, maximum number of animal in an image = 29, SD = 4.16, median = 1). Duclos et al. (2018) included dugong resights in their results so we could not compare our findings to theirs.
- Duclos et al. (2018) had substantially higher number of certain detections (reviewer is 100% certain that the detection is a dugong) compared to our review (79 certain detections versus 53 respectively). The largest difference was found in images collected in survey block 2.
- Naturally, the level of uncertain detections was higher in our review than in Duclos et al. (2018).
- We noted that the level of uncertainty was, in some images, due to a combination of low image quality, environmental conditions and the dugong's behaviour. For example, in image CF044270.jpg we detected several dugongs underwater in water visibility 2, beaufort seastate 1 and no glare. However, in this type of water visibility and because of motion blur effect in the image it was impossible to identify with certainty some potential dugong detection. For this particular image, we asked three different experienced reviewers to assess the image. Reviewer 1 found 47 certain dugongs, reviewer 2 = 29 dugongs, reviewer 3 = 20 dugongs.

TABLE 1. *COMPARATIVE RESULTS OF DUGONG DETECTIONS MADE BY JCU STAFF VERSUS DUCLOS ET AL. (2018).*

Block number	# of reviewed images		# of dugongs detected (excluding resights)		# of certain dugong detections		# of uncertain dugong detections	
	JCU	Duclos et al. 2018	JCU	Duclos et al. 2018	JCU	Duclos et al. 2018	JCU	Duclos et al. 2018
1	103	103	5	Unknown	5	5	0	4
2	92	94	86	Unknown	42	72	44	23
3	56	45	4	Unknown	2	0	2	0
4	30	32	6	Unknown	4	2	2	4
6	0	11	0	Unknown	0	0	0	2
Total	**281**	**285**	**101**	**na**	**53**	**79**	**48**	**33**

4 CONCLUSION AND RECOMMENDATIONS

- We manually reviewed a subset of images collected during an occupied imagery survey conducted in New Caledonia (source Duclos et al. 2018). The review was undertaken as part of a larger study to retrospectively assess the efficacy and logistical settings of a range of occupied imagery survey approaches on the level and quality of dugong detections.
- As a side investigation we compared our manual review of the New Caledonia dataset to the results found in Duclos et al. (2018; "Tableau 3" page 38).
- While we could not compare the total number of dugongs detected between our review and Duclos et al.'s (2018) we found that the level of certainty in the dugong detections varied greatly between the two reviews, especially in survey block 2 where a relatively high number of dugongs were detected compared to other blocks.
- The discrepancy in the level of certainty of dugong detections may have a substantial effect on the dugong abundance estimations (as only certain detections should be included in the abundance analysis). A re-analysis of the dugong abundance based on our review would provide a better understanding of the difference between to two reviews.
- The AI model used by Duclos et al. (2018) was provided limited training based on a very small dataset to detect dugongs. Thus, we recommend that the entire dataset collected by Duclos et al. (2018) should be re-analysed using a more sophisticated highly-trained AI model. A new estimate of dugong abundance could be generated from this counter analysis.

5 REFERENCES

Duclos, G., C. Aubert, R. Dambreville, G. Le Moguedec, B. Roux (2019). "Étude de la distribution de la population de dugongs de Nouvelle-Calédonie par survol aérien." *Rapport d'analyse des données de la campagne de novembre 2018. 53p+ annexes*

Raudino, H. C., C. Cleguer, M. A. Hamel, M. Swaine, and K. A. Waples (2022). "Species identification of morphologically similar tropical dolphins and estimating group size using aerial imagery in coastal waters. Mammalian Biology 1-11.

6 APPENDICES

6.1 APPENDICE A

TABLE A.1. *DETAIL OF IMAGES WITH DUGONG DETECTION FROM THE REVIEW PERFORMED BY JCU.*

Image ID & Certainty level	Survey block number	Number of dugongs detected
CF040003.jpg	**Bloc1s8**	**1**
Certain		1
CF041159.jpg	**Bloc1s10**	**1**
Certain		1
CF041254.jpg	**Bloc1s10**	**1**
Certain		1
CF041999.jpg	**Bloc1s12**	**1**
Certain		1
CF042000.jpg	**Bloc1s12**	**1**
Certain		1
CF043133.jpg	**Bloc2s0**	**1**
Certain		1
CF043286.jpg	**Bloc2s1**	**7**
Certain		7
CF043341.jpg	**Bloc2s1**	**7**
Uncertain		1
Certain		6
CF043342.jpg	**Bloc2s1**	**1**
Certain		1
CF043685.jpg	**Bloc2s1**	**1**
Uncertain		1
CF043686.jpg	**Bloc2s1**	**1**
Uncertain		1
CF044270.jpg	**Bloc2s2**	**20**
Uncertain		16
Certain		4
CF044271.jpg	**Bloc2s2**	**8**
Uncertain		7
Certain		1
CF044571.jpg	**Bloc2s3**	**2**
Uncertain		1
Certain		1
CF044588.jpg	**Bloc2s3**	**1**
Uncertain		1
CF044589.jpg	**Bloc2s3**	**2**
Uncertain		2
CF044678.jpg	**Bloc2s3**	**1**
Uncertain		1
CF044679.jpg	**Bloc2s3**	**1**
Certain		1
CF044687.jpg	**Bloc2s3**	**1**

Certain		1
CF044690.jpg	**Bloc2s3**	**4**
Uncertain		3
Certain		1
CF044691.jpg	**Bloc2s3**	**1**
Certain		1
CF044692.jpg	**Bloc2s3**	**1**
Uncertain		1
CF044709.jpg	**Bloc2s3**	**1**
Certain		1
CF044852.jpg	**Bloc2s4**	**2**
Uncertain		2
CF044865.jpg	**Bloc2s4**	**1**
Certain		1
CF044893.jpg	**Bloc2s4**	**1**
Uncertain		1
CF044926.jpg	**Bloc2s4**	**1**
Uncertain		1
CF045831.jpg	**Bloc2s6**	**2**
Certain		2
CF046047.jpg	**Bloc2s6**	**2**
Certain		2
CF046048.jpg	**Bloc2s6**	**2**
Uncertain		2
CF046419.jpg	**Bloc2s7**	**1**
Uncertain		1
CF046620.jpg	**Bloc2s7**	**1**
Certain		1
CF046747.jpg	**Bloc2s7**	**1**
Certain		1
CF046880.jpg	**Bloc2s8**	**1**
Certain		1
CF047200.jpg	**Bloc2s8**	**1**
Certain		1
CF047202.jpg	**Bloc2s8**	**1**
Certain		1
CF047263.jpg	**Bloc2s8**	**2**
Certain		2
CF047264.jpg	**Bloc2s8**	**2**
Certain		2
CF047314.jpg	**Bloc2s8**	**1**
Certain		1
CF047367.jpg	**Bloc2s9**	**1**
Certain		1
CF047418.jpg	**Bloc2s9**	**2**
Uncertain		2
CF048051.jpg	**Bloc4s1**	**1**
Certain		1

CF049893.jpg	**Bloc4s4**	**2**
Uncertain		1
Certain		1
CF050230.jpg	**Bloc4s5**	**1**
Certain		1
CF051085.jpg	**Bloc4s7**	**1**
Uncertain		1
CF051145.jpg	**Bloc4s7**	**1**
Certain		1
CF052438.jpg	**Bloc3s0**	**2**
Uncertain		1
Certain		1
CF052439.jpg	**Bloc3s0**	**2**
Uncertain		1
Certain		1
Total		**101**