SUPPLEMENTARY MATERIAL

Better together: Analysis of integrated acoustic and visual methods when surveying a cetacean community

Dalpaz L, Paro AD, Daura-Jorge FG, Rossi-Santos M, Norris TF, Ingram SN, Wedekin LL*
*corresponding author: leowedekin@gmail.com

Table of contents:

S1: CRITERIA USED FOR CLASSIFICATION OF ACOUSTIC DETECTIONS LOCALIZATION

Table S1. Description of criteria used to classify acoustic detections localization. The classification consists in a qualitative scale with Quality 1 (Q-1) being the most reliable and Quality 5 (Q-5) the least reliable.

Quality score	Description
Q1	At least five forward angles and five backward angles and angles that showed a good convergence (within a small area) on both sides. The difference among angles should be of at least 30°.
Q2	At least five forward angles and four backward angles and a sparser convergence of angles on both sides. The difference among angles must be at least 30°.
Q3	At least three forward angles and one or two backward angles; or no forward and at least five angles backward angles; or at least five forward angles and no backward angles. Any of the criteria above Q3 must configure a good convergence of angles on at least one side. The difference between the angles must be at least 30°.
Q4	At least three forward angles and one or two backward angles; or no forward angles and at least five backward angles; or at least five forward angles and no backward angles. Any of the criteria above Q4 configures a sparser convergence of angles on at least one side. The difference between the angles must be at least 30°.
Q5	At least three to six angles that have converged. Angles must be between 70° and 110°. The difference between angles can be less than 30°.

S2: SUMMARIZED RESULTS OF THE FOUR SURVEYS

Table S2: Summary of acoustic and visual detections made in the four surveys in Santos Basin, Brazil. Number of the survey, method (acoustic or visual), taxa identified, number of detections in each taxa and total of paired detections (matches) in the survey.

Survey #	Method	Taxa identified	Number of detections	Matches
1	A	Delphinidae	58	18
		Kogia sp.	1	
		Odontoceti	8	
		Physeter macrocephalus	6	
		Pontoporia blainvillei	1	
	V	*Delphinidae*	13	
		Feresa attenuata	1	
		Grampus griseus	2	
		Physeter macrocephalus	5	
		Stenella attenuata	3	
		Sotalia guianensis	1	
		Stenella longirostris	1	
		Stenella sp.	5	
		Tursiops truncatus	1	
2	A	Delphinidae	83	28
		Kogia sp.	1	
		Odontoceti	6	
		Physeter macrocephalus	7	
	V	Delphinidae	8	
		Delphinus sp.	1	
		Grampus griseus	7	
		Megaptera novaeangliae	7	
		Odontoceti	3	
		Physeter macrocephalus	1	
		Stenella attenuata	4	
		Steno bredanensis	4	
		Stenella clymene	1	
		Stenella frontalis	13	
		Stenella longirostris	3	
		Stenella sp.	1	
		Tursiops truncatus	4	
3	A	Delphinidae	87	35
		Kogia sp.	4	
		Megaptera novaeangliae	9	
		Odontoceti	31	
		Physeter macrocephalus	2	
		Ziphiidae	2	
	V	Delphinidae	22	
		Delphinus sp.	2	

		Grampus griseus	1	
		Globicephala sp.	13	
		Globicephala sp. + *Steno bredanensis* + *Stenella* sp. + *Tursiops truncatus*	1	
		Megaptera novaeangliae	18	
		Odontoceti	5	
		Stenella attenuata	3	
		Steno bredanensis	3	
		Stenella clymene	1	
		Stenella frontalis	8	
		Stenella longirostris	3	
		Stenella sp.	2	
		Tursiops truncatus	2	
4	A	Delphinidae	67	27
		Feresa attenuata	1	
		Kogia sp.	2	
		Odontoceti	15	
		Physeter macrocephalus	2	
		Pontoporia blainvillei	1	
		Ziphiidae	1	
	V	Delphinidae	12	
		Delphinus sp.	1	
		Feresa attenuata	1	
		Grampus griseus	1	
		Physeter macrocephalus	1	
		Stenella attenuata	1	
		Steno bredanensis	1	
		Steno bredanensis + *Grampus griseus*	1	
		Steno bredanensis + *Tursiops truncatus*	1	
		Stenella frontalis	19	
		Sotalia guianensis	5	
		Stenella sp.	1	
		Tursiops truncatus	4	
Total	**A**		**395**	**108**
	V		**222**	
	A+V		**617**	

S3: UNSCHEDULED STOPPAGES BY EACH METHOD

The causes of unscheduled stoppage were determined and compared between methods (Figure S1). Acoustic method stopped due to technical and operational reasons, such as equipment failure (n = 35.7 hours), or due to depth limitations for towing the hydrophone array in shallow waters < 20 m (n = 33.3 hours). Duration of stoppages due to technical issues decreased along surveys. Visual stoppages (n = 58.0 hours) and simultaneous stoppages of both methods (n = 55.6 hours) occurred entirely due to unfavorable climatic conditions. In the third survey, conditions were restrictive for both methods (n = 45.9 hours), while in the first, second, and fourth surveys conditions affected mainly or exclusively visual method (see Table 1 in the main text).

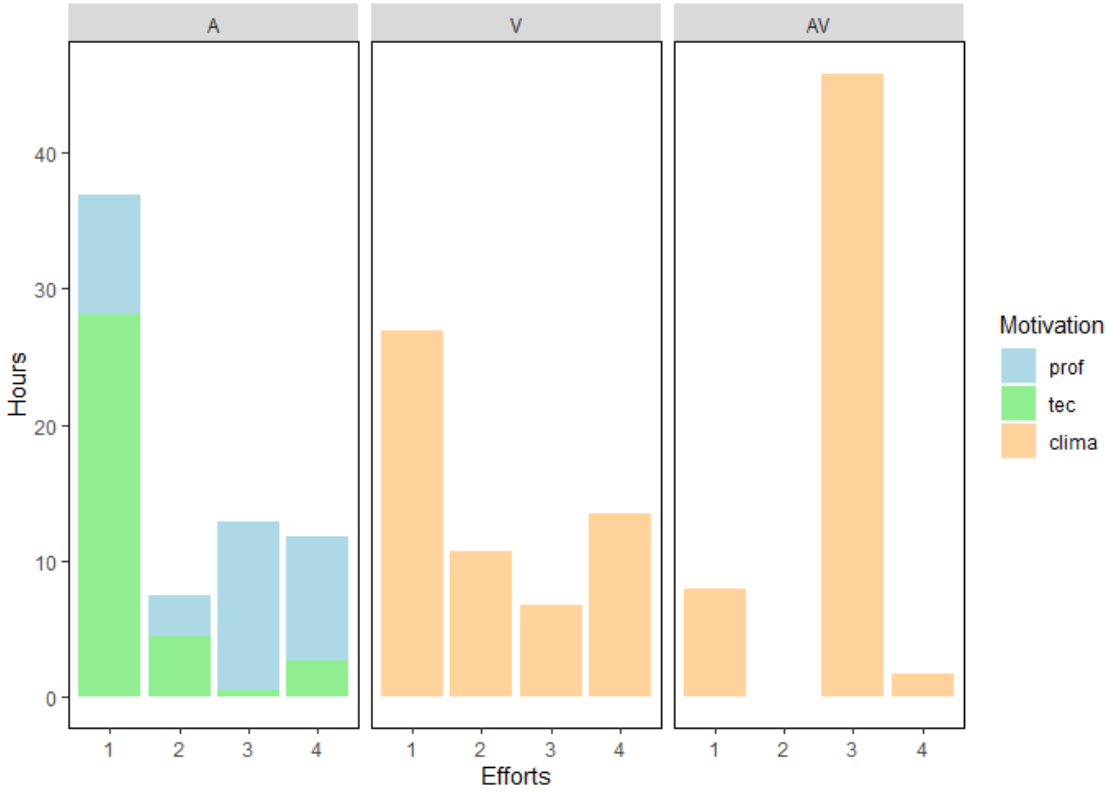

Figure S3. Duration and reasons for effort stoppages by each method in each survey. Number of stoppages hours of acoustic method (A), visual method (V), and by both methods (AV). Efforts refers to surveys 1, 2, 3 and 4. The reasons include poor weather conditions (clima), technical or operational issues (tec) and limiting depth (prof).

S4: TAXONOMY OF LONG-RANGE DETECTION

Taxonomic composition of acoustic and visual furthest detections (> 1 nautical mile) was graphically compared (Figure S2). Furthest acoustic detections (n = 36) were mostly from individuals of Delphinidae family (n = 29) while furthest visual detections (n =10) were almost entirely from large cetaceans (n = 9).

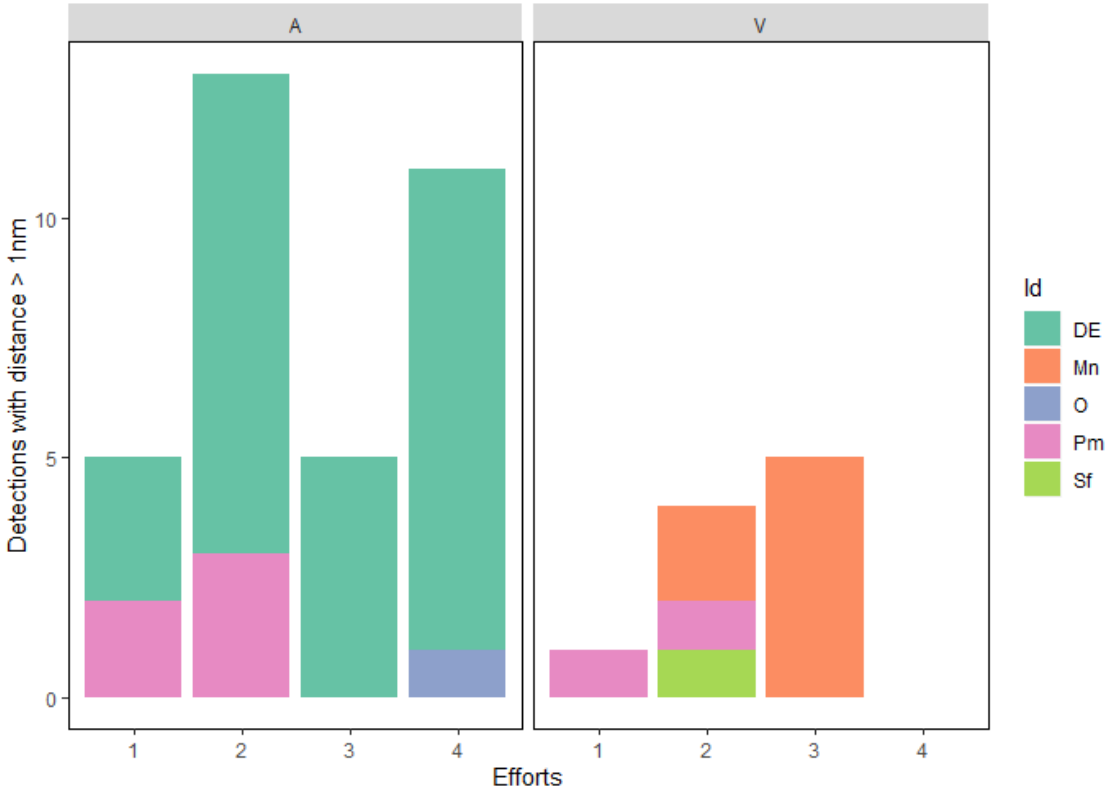

Figure S4. Taxonomic identification of long-range detections from each method in each survey. Number of long-range detections (>1nm) of acoustic (A) and visual (V) methods in surveys 1, 2, 3 and 4. Acoustic detections were field-identified as: Delphinidae (DE), Odontoceti (O) and *Physeter microcephalus* (Pm). Visual detections were field-identified as: *Megaptera novaeangliae* (Mn), *Physeter microcephalus* (Pm) and *Stenella frontalis* (Sf). Visual method did not record any long-range detection (>1nm) during the 4th survey.

S5: TAXA COMPOSITION IDENTIFIED BY METHOD AND SURVEY

Taxonomic composition of acoustic and visual detections was compared and differed between methods (Figure S3). Visual method was more efficient in terms of taxonomic identification of cetaceans identifying much more species. Most acoustic detections were identified at family level (75.1%, n = 298). Throughout the four surveys, Franciscana dolphin (*Pontoporia blainvillei*), *Kogia* spp. and Ziphiidae were only acoustically detected. Interestingly, humpback whales (*Megaptera novaeangliae*) were only visually detected in the second survey (n = 7). During the third survey, this species was recorded by both methods, with 17 visual detections and nine acoustic detections. Sperm whales (*Physeter macrocephalus*) were recorded mostly by the acoustic method (70.8%, n = 17).

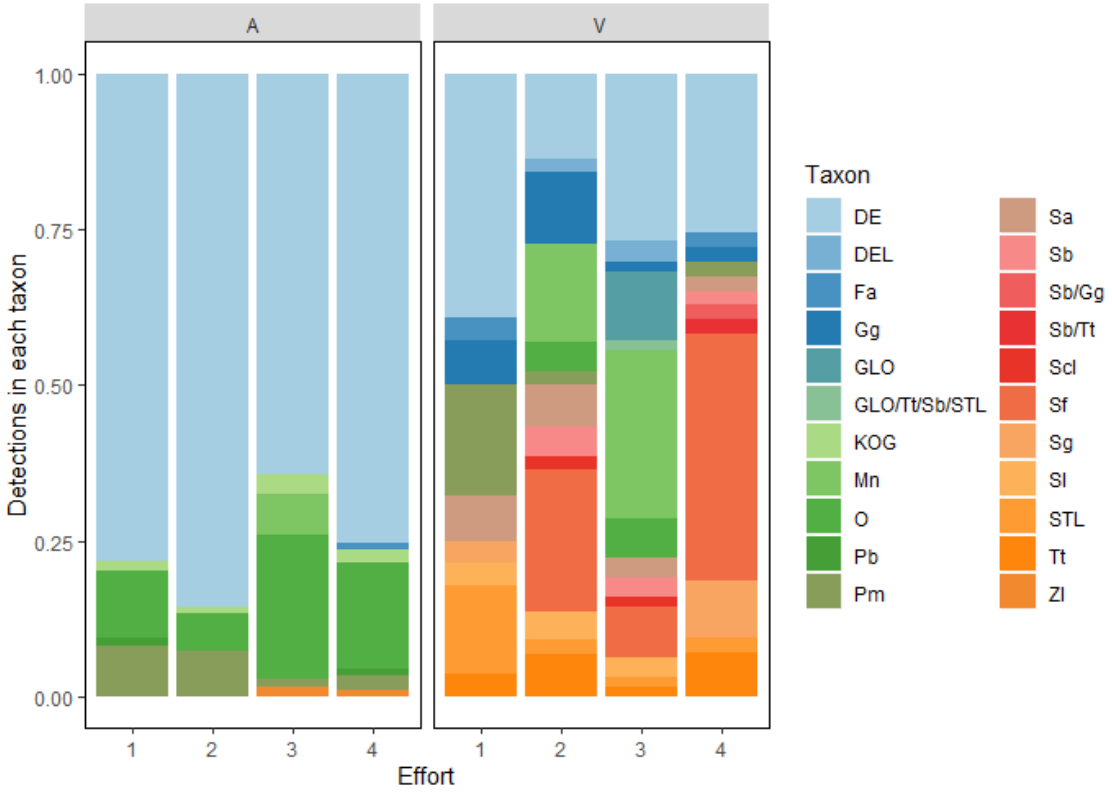

Figure S5. Percentage of taxa composition identified by each method in each survey. Taxonomic identification correspond to the most specific taxa that each method attributed to each detection, and include: DE (Delphinidae), DEL (*Delphinus* spp.), Fa (*Feresa attenuata*), Gg (*Grampus griseus*), GLO (*Globicephala* sp.), KOG (*Kogia* sp.), Mn (*Megaptera novaeangliae*), O (Odontoceti), Pb (*Pontoporia blainvillei*), Pm (*Physeter macrocephalus*), Sa (*Stenella attenuata*), Sb (*Steno bredanensis*), Scl (*Stenella clymene*), Sf (*Stenella frontalis*), Sg (*Sotalia guianensis*), Sl (*Stenella longirostris*), STL (*Stenella* sp.), Tt (*Tursiops truncatus*), ZI (Ziphiidae). Detections with more than one taxon (GLO/Tt/Sb/STL, Sb/Gg and Sb/Tt) correspond to mixed groups that where visually identified.

S6: MATCH ANTICIPATION

Methods differed in number of preceded detections (Figure S4). Acoustic method preceded 55% (n = 60) of matched detections, while visual method preceded 32.1 % (n = 35). Simultaneous detections corresponded to 12.9% (n = 14) of common detections.

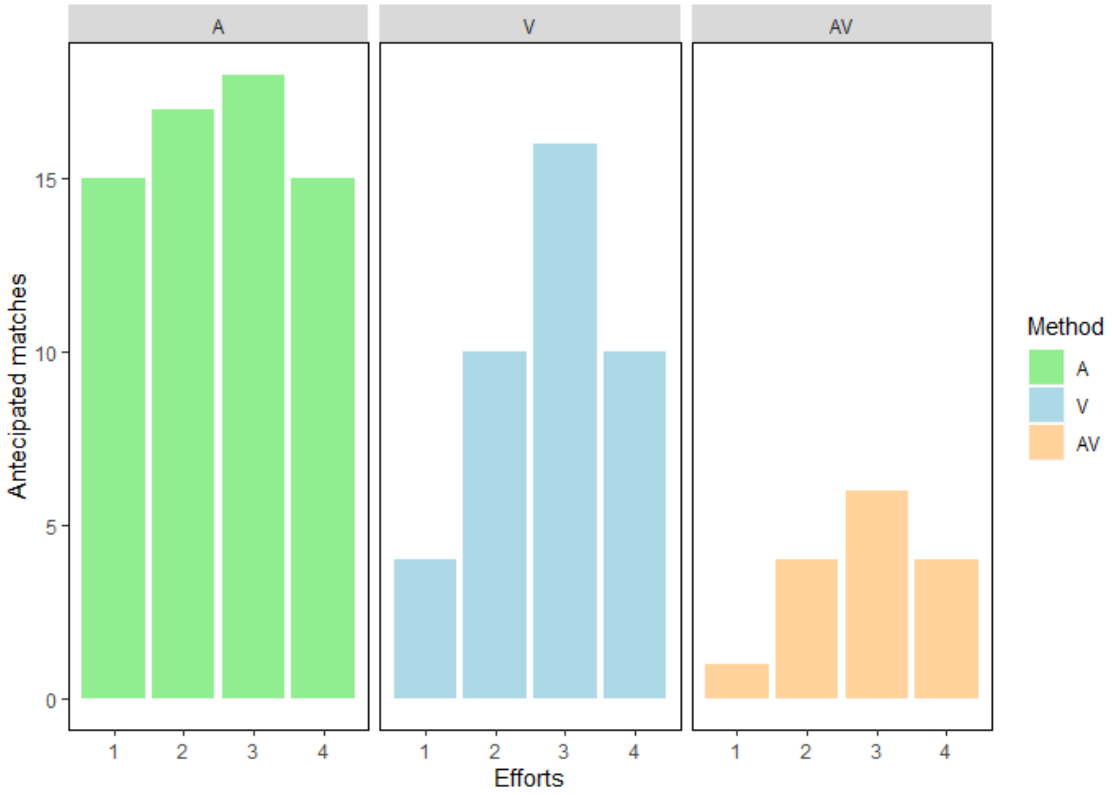

Figure S6. Number of matches (paired detections) anticipated by acoustic method (A), by visual method (V) and simultaneous matches (AV) in sampling campaigns 1, 2, 3 and 4.

S7: ANTICIPATION INTERVAL BY METHOD

Methods did not vary significantly in terms of anticipation interval (Figure S5).

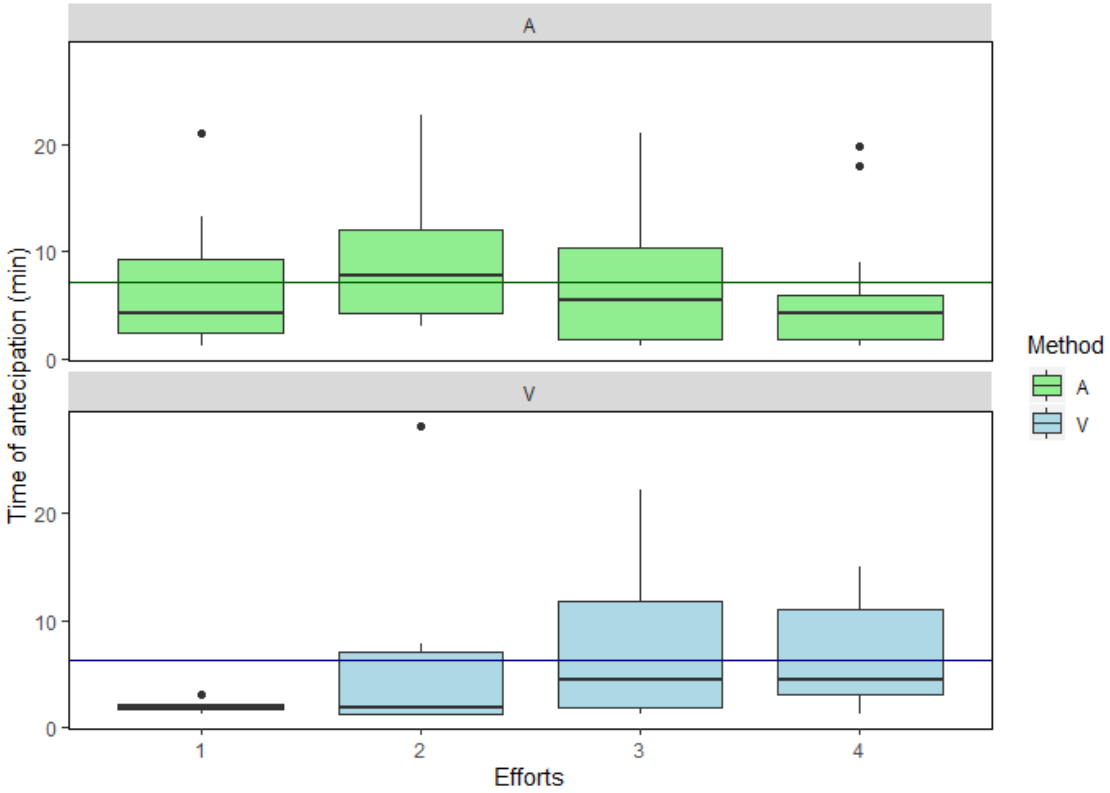

Figure S7. Mean anticipation time (in minutes) for each method in paired detections (matches). Mean anticipation time in minutes and standard error in surveys 1, 2, 3, and 4 for acoustic (A) and visual (M) methods.