

Short Communication: Comparing group size estimates of Mediterranean dolphins using visual and passive acoustic data

CAMILLE OLLIER^{1,2}, OLIVER BOISSEAU³, VINCENT RIDOUX^{1,2} AND AURIANE VIRGILI⁴

Contact email: ollier.cam@gmail.com

ABSTRACT

Accurately estimating dolphin group size is essential for abundance estimation and population assessment, but it can be challenging using passive acoustic methods. This study compared visual data, assumed to be the gold standard, and passive acoustic data to estimate group size from a double-platform survey implemented in the vessel component of the ACCOBAMS Survey Initiative in the Mediterranean Sea. Simultaneous data collection resulted in 30 duplicate events, showing no significant correlation between visually and acoustically estimated group sizes. Hence, the number of simultaneous click trains obtained from passive acoustic data may provide different information, as this index is not proportional to the group size recorded with the visual method. Currently, visual estimates remain the most reliable method.

KEYWORDS: DOLPHINS; GROUP SIZE ESTIMATION; SURVEY-COMBINED; ACOUSTICS; MEDITERRANEAN

INTRODUCTION

Dolphins are highly social animals, often forming groups that range from a few individuals to hundreds (Jefferson & Rick, 2018). Estimating group size, i.e., the number of individuals in a group, is a critical task for population assessments and behavioural studies (Gerrodette *et al.*, 2019). Accurate group size estimates are essential for unbiased abundance estimation. In conventional line-transect distance sampling, the density of groups is estimated and multiplied by the estimated group size to estimate abundance (Buckland *et al.*, 2001). Group size may also be included as a covariate in the detection function, as it may affect the detection probability (Marques & Buckland, 2004). For example, larger groups are more likely to be seen at the surface. Both approaches assume that group size is accurately quantified. Although visual surveys have traditionally been the primary method for estimating dolphin group size, estimates can vary between observers (Gerrodette *et al.*, 2002). However, visual surveys are limited to daylight hours and favourable weather conditions. Technical advances have extended the application of line-transect distance sampling surveys to acoustic-based surveys using towed hydrophone arrays (Marques *et al.*, 2013) as a complement to visual surveys (Dalpaz *et al.*, 2021). However, acoustic estimation of group size is difficult for dolphins as they use a wide range of vocalisations that change considerably depending on the behavioural context (Janik, 2000; Gallo *et al.*, 2023). Additionally, not all individuals in a group vocalise; some may remain silent while still receiving and using acoustic information from conspecifics (Krause & Ruxton, 2002; Gregg *et al.*, 2007; Henderson *et al.*, 2011). When a group has a high level of acoustic activity, calls may overlap, making it difficult to identify every vocalising individual (Henderson *et al.*, 2011). To overcome this problem and accurately estimate density, cue counting can be used to estimate the density of cues, such as calls,

¹ Centre d'Etude Biologiques de Chizé, UMR 7372 CNRS, La Rochelle Université, Chizé, France

² Observatoire PELAGIS, UAR 3462 CNRS, La Rochelle Université, La Rochelle, France

³ Marine Conservation Research, Kelvedon, UK

⁴ Share the Ocean, Larmor-Baden, France

produced by animals which can then be converted to animal density using the cue production rate of the species (Marques *et al.*, 2009). This method requires detailed behavioural information on the rate of cue production and its variations (e.g., vocalisation rates), and this information is scarce for most species (Mellinger *et al.*, 2007). Thus, it is challenging to estimate group size based on vocalisations alone. The combination of visual and passive acoustic methods can be beneficial for investigating the relationship between vocalising animals and the number of individuals. Using a double-platform framework, where visual and passive acoustic data are collected simultaneously, sightings can be used to validate acoustic data by providing direct information on group size alongside vocal activity (Van Parijs *et al.*, 2002; Barlow & Taylor, 2005). In this study, we assessed the relationship between acoustic and visual group sizes as a first step toward estimating dolphin abundance, using a double-platform line transect survey in the Mediterranean Sea as a case study. We also aimed to determine whether acoustic group sizes could be used directly to estimate abundance. We hypothesised that acoustic group size would be underestimated but proportionate to visual group size, because not all dolphins may vocalise within a given detection window when they are present in groups (Gregg *et al.*, 2007; Rankin *et al.*, 2020; Dalpaz *et al.*, 2021).

MATERIALS & METHODS

We used vessel-based visual sightings and passive acoustic data collected simultaneously during the ACCOBAMS Survey Initiative (ASI) in the summer 2018 aboard the R/V *Song of the Whale* (ACCOBAMS, 2021). This study focused on dolphins in the western and central Mediterranean Sea, including the bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*), long-finned pilot whale (*Globicephala melas melas*), Risso's dolphin (*Grampus griseus*), rough-toothed dolphin (*Steno bredanensis*), and the most commonly encountered, striped dolphin (*Stenella coeruleoalba*). Visual and passive acoustic data were collected using a double-platform framework during daylight hours, whenever the observation conditions were appropriate (i.e., Beaufort sea state ≤ 4) and when local water depths were greater than 50 m to allow the deployment of towed hydrophones. Both platforms operated independently, and all visual operations were conducted in passing mode.

During the visual effort, two observers were positioned on a 5 m elevated platform to search for cetaceans. An observer was positioned on either side of the platform: the first observer scanned the starboard side from 340° to 90°, and the second observer scanned the port side from 270° to 20°, with 0° representing the bow. They observed their respective areas with naked eyes and used binoculars to confirm species identity when necessary. A visual event was defined as the detection of a group of animals within the area scanned by the observers. For each visual event, the observers reported the species and the best estimate of group size to a dedicated data logger. The visual survey team consisted of at least four members who rotated between port observer, starboard observer, data logger and helm person, performing each role for up to one hour before taking at least two hours of rest to prevent fatigue. Duplicate sightings made by both observers in the overlap area were removed.

Passive acoustic data were collected simultaneously using a 400 m towed hydrophone array. The hydrophone array was housed in an oil-filled tube and consisted of a pair of hydrophones in a linear configuration. The two hydrophone elements (Magrec HP03), spaced 0.25 m apart, had a sensitivity of -204 dB re 1V/ μ Pa with a flat frequency response (± 3 dB) from 1 to 100 kHz in the frequency band of most odontocete vocalisations. Preamplifiers with 29 dB gain were used to prevent voltage drop between the array and the research vessel. The outputs from the hydrophone pair were digitised at a sample rate of 192 kHz and monitored in real-time using a click detector in PAMGuard (Gillespie *et al.*, 2008), a passive acoustic monitoring software package. The click detector outputs were compressed into binary storage files in PAMGuard, and files were manually analysed *post hoc* with a focus on dolphins (i.e., not sperm or beaked whales) based on echolocation clicks. Acoustic event identification and group size estimation were performed following the methodology described in Ollier *et al.* (2023). An acoustic event was defined as sequences of clicks, or click trains, produced by a group of animals passing abeam that showed a consistent change in bearing on the click detector (i.e., from the bow to the stern of the vessel). When multiple click trains occurred simultaneously along the same trajectory, they were used to approximate the number of individuals in the group as an estimate of acoustic group size. Sequences of clicks that did not show a consistent change in bearing were not considered as acoustic events. They were excluded because the localisation of animals would not be precise enough to allow for reliable abundance estimates. As

with visual events, acoustic group sizes were reported as the best estimate of the number of animals in each event. Estimates from both detection types were used in subsequent analyses. Due to the overlapping frequency ranges of echolocation clicks among the dolphin species studied, species identification from acoustic recordings was not possible (Soldevilla *et al.*, 2008; Ollier *et al.*, 2023). Therefore, species could not be compared, and all species studied were pooled for both acoustic and visual data analyses.

Since the visual and acoustic platforms operated independently, duplicates were identified post-survey using the method described in Ollier *et al.* (2023). A duplicate was defined as a group of animals (either single or multiple individuals) detected by both visual and acoustic platforms. Duplicates were identified using a two-stage classification tree based on time and distance thresholds. Since the visual effort was conducted from the vessel and the acoustic effort was conducted 400 m behind the vessel, there was a time and spatial lag due to the vessel and animal movements. The first step of the classification tree corrected for the movement of the vessel, while the second step accounted for the movement of the animals. The means and standard deviations of group sizes for both visual and acoustic duplicate events were estimated to quantify variability across events. Then, a linear relationship was used to examine the relationship between visual and acoustic group sizes from duplicate events. Analyses were performed using the R software (version R. 4.3.0, R Core Team, 2023).

RESULTS & DISCUSSION

Transects where visual and acoustic data were collected concurrently in good conditions (Beaufort sea-state ≤ 4) totalled 6,679 km of effort (Fig. 1A). A total of 30 duplicate events were identified. The estimated group size was higher for visual events, with a mean of 13.9 (SD = 16.8) individuals per event, than for acoustic events, with a mean of 3.8 (SD = 1.6) individuals per event. Visual group sizes varied considerably between events, while acoustic group sizes remained relatively stable. At the extreme, the ratio between acoustic and visual group sizes could be as high as 10, with a visual group size of 70 individuals and the corresponding acoustic group size of only nine individuals. The analysis of the acoustic data using PAMGuard showed that, for the event shown in Figure 1B, only about nine individuals were acoustically active within a timeframe of approximately 10 minutes around the visual event. Linear regression analysis was performed to test whether visual group size correlated with acoustic group size (Fig. 1C). No significant correlation was observed between the group sizes estimated by the two detection methods ($F_{1,28} = 2.834$; $p = 0.1034$; $R^2 = -0.0595$). When removing the two outliers at the top of the graph (Fig. 1D), the regression becomes slightly negative but still not significant ($F_{1,26} = 1.423$; $p = 0.2436$; $R^2 = 0.0154$). In both cases, the confidence intervals contain a flat regression line with slope = 0. These results support the hypothesis that acoustic group size is underestimated relative to visual group size, but they do not support the hypothesis that acoustic group size is proportionate to visual group size. Therefore, it is not feasible to derive a constant factor to correct acoustic group size in our study. The number of distinct tracks in the PAMGuard data does not adequately represent group size.

Comparison with other studies is challenging since most rely on vocalisation rates rather than direct acoustic counts of individuals based on click trains (Jones & Sayigh, 2002; Van Parijs *et al.*, 2002; Henderson *et al.*, 2011). The most comparable study to ours used a combination of acoustic and visual line transects to study Ganges river dolphins (*Platanista gangetica gangetica*; Richman *et al.*, 2014). Their methodology for estimating acoustic group size, based on counting individuals from click trains, was similar to ours. They compared the group size of duplicate events between the two detection types and found a good match between visual and acoustic group sizes. Ganges river dolphins, which live in turbid environments, are effectively blind and rely strongly on their hearing, producing echolocation clicks as continuous emitters (Jensen *et al.*, 2013), which may make them easy to detect acoustically. Harbour porpoises also tend to echolocate continuously (Akamatsu *et al.*, 2007), but individual clicks are often too dispersed, and high variability in click production rate has led some authors to question whether the number of clicks directly correlates with the number of animals present (Jacobson *et al.*, 2017). Additionally, porpoises and Ganges river dolphins form small groups of only a few individuals (Scheidat *et al.*, 2008; Sinha & Kannan, 2014) unlike Mediterranean dolphins, which typically form larger groups (Boisseau *et al.*, 2010; Panigada *et al.*, 2024). Estimating acoustic group size becomes particularly difficult with large groups and could explain the lack of correlation observed in our study. For abundance estimation, when individuals

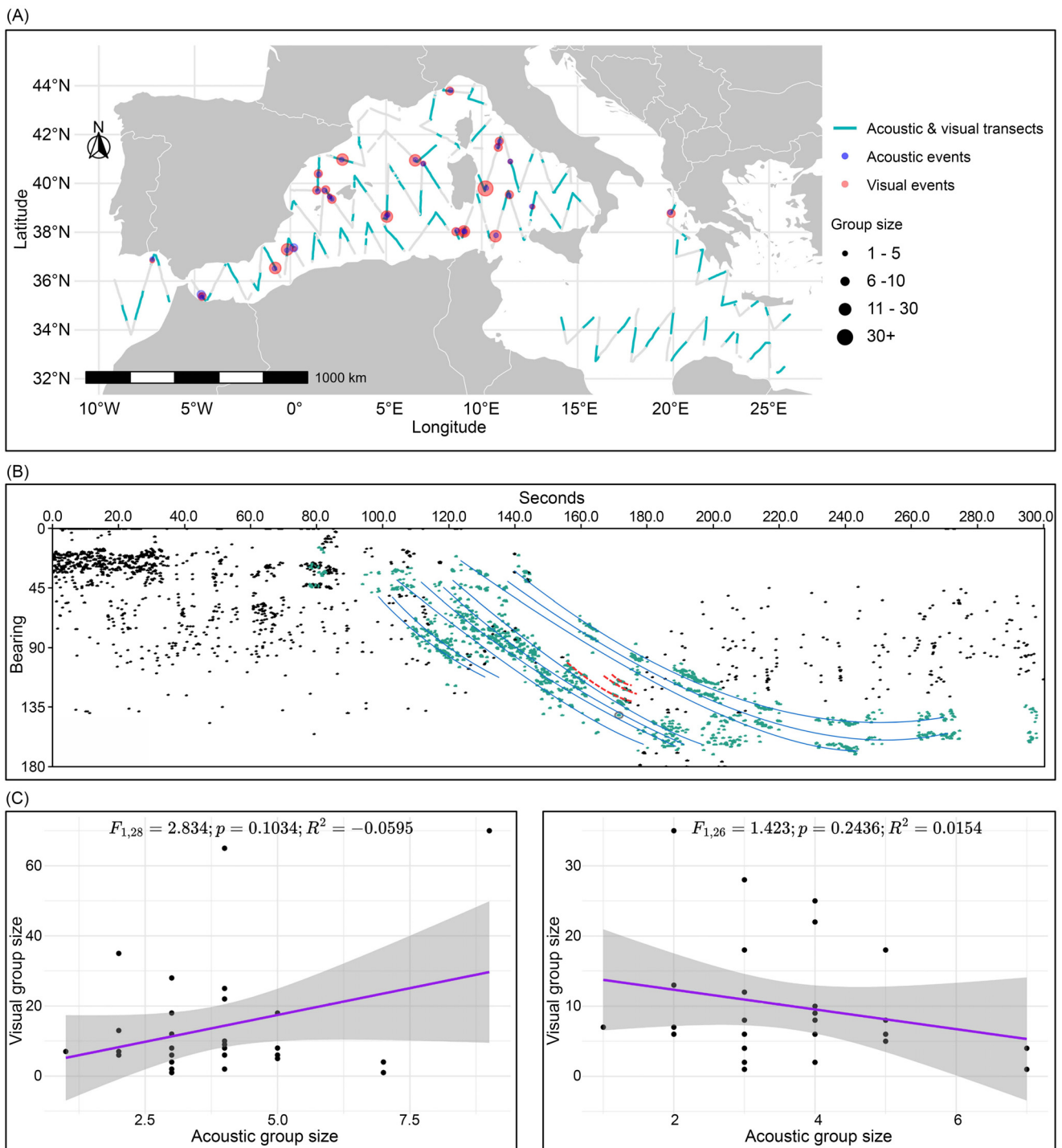


Figure 1. (A) Survey effort and duplicate events recorded during the ASI vessel-based survey in the Mediterranean Sea. The map shows the linear transects sampled by the R/V *Song of the Whale*, with acoustic events shown in blue and visual events in red. The size of the dots corresponds to the measured group size. Blue lines represent the acoustic-visual transects. (B) Example of a five-minute period of acoustic effort displayed in the PAMGuard click detector module. The y-axis shows bearing angles and the x-axis represents time. Each point represents an acoustic signal, with coloured dots indicating signals attributed to dolphins. The number of acoustically active individuals per acoustic event was determined as the number of tracks that occurred at the same time. In this example, approximately nine individuals were detected acoustically (indicated by blue lines), with a corresponding visual event that measured a group of 70 individuals. Examples of tracks that did not pass abeam are shown as red dashed lines; acoustic group sizes may be underestimated due to these and other undetected tracks. (C) Comparison between visual and acoustic group sizes of Mediterranean dolphins. Each point represents a duplicate event, with estimated visual group size on the y-axis and the estimated acoustic group size on the x-axis. The purple line represents the linear regression, and the shaded grey area represents the 95% confidence intervals. (D) Comparison between visual and acoustic group sizes of Mediterranean dolphins, as in Figure 1C, with two outliers at the top of the graph removed.

occur in groups, accurate measurement of the group size for each event becomes critical (Buckland *et al.*, 2001). The lack of correlation can lead to a number of tentative explanatory hypotheses: (1) the acoustic recordings may have captured only a subset of the group, namely those animals that were echolocating. This may be due to the effect of eavesdropping, whereby individuals in a group may improve foraging efficiency and reduce energetic costs by listening to and interpreting acoustic signals produced by conspecifics (Barrett-lennard *et al.*, 1996; Jones & Sayigh, 2002; Krause & Ruxton, 2002). (2) Only individuals moving from in front to behind the hydrophone array were counted, and not all animals in a group were likely to move in the same way relative to the array and/or echolocate continuously as the array moved past them, so that only part of the group was detected and counted. (3) The third assumption is a mixture of the two, implying that it is difficult to disentangle availability bias from perception bias using the acoustic method.

Because of these challenges, visual group size estimation remains the most reliable method in this context. Acoustic group size could not be used to estimate abundance because it did not correlate well with visual observations or reliably reflect actual group size. Estimating abundance at the group level (i.e., counting groups of animals only) can overcome the problem of estimating group size, but in general, it is less useful, and the definition of a group may be inconsistent. For example, in visual surveys, such as the ASI surveys (Panigada *et al.*, 2024), a large group seen from the air could appear as two separate groups from a vessel. Some studies combining visual and passive acoustic data have assumed that acoustic group size was equal to visual group size for abundance estimates (Gerrodette *et al.*, 2011; Martin *et al.*, 2020). Using visual group size as a proxy provides a practical starting point for estimating acoustic group size in dolphins. In our study, visual estimates remain the most reliable method at present. Further research on acoustic group size is needed, particularly when conducted alongside visual observations, to improve our understanding of vocal behaviour (e.g., ACCURATE project⁵). Echolocation rates of dolphins should also be investigated to facilitate the application of cue-counting methods for abundance estimation.

ACKNOWLEDGEMENTS

We thank ACCOBAMS, including both its technical and financial partners, for making this survey possible and providing the dataset collected during the vessel-based part of the ASI. We are grateful to the government authorities for their permissions and logistical support in the field. Many thanks to the crew of the R/V *Song of the Whale* and all the observers who contributed to the data collection during the ASI. CO's doctoral research was funded by *Centre National de la Recherche Scientifique*.

REFERENCES

- ACCOBAMS (2021). Estimates of abundance and distribution of cetaceans, marine megafauna and marine litter in the Mediterranean sea from 2018–2019 surveys. Monaco: ACCOBAMS – ACCOBAMS Survey Initiative..
- Akamatsu, T., Teilmann, J., Miller, L.A., Tougaard, J., Dietz, R., Wang, D., Wang, K., Siebert, U., & Naito, Y. (2007). Comparison of echolocation behaviour between coastal and riverine porpoises. *Deep Sea. Res. II* 54(3–4): 290–297. <https://doi.org/10.1016/j.dsr2.2006.11.006>
- Barlow, J., & Taylor, B.L. (2005). Estimates of sperm whale abundance in the northeastern temperate pacific from a combined acoustic and visual survey. *Mar. Mammal Sci.* 21(3): 429–445. <https://doi.org/10.1111/j.1748-7692.2005.tb01242.x>
- Barrett-lennard, L.G., Ford, J.K.B., & Heise, K.A. (1996). The mixed blessing of echolocation: differences in sonar use by fish-eating and mammal-eating killer whales. *Anim. Behav.* 51(3): 553–565. <https://doi.org/10.1006/anbe.1996.0059>
- Boisseau, O., Lacey, C., Lewis, T., Moscrop, A., Danbolt, M., & McLanaghan, R. (2010). Encounter rates of cetaceans in the mediterranean sea and contiguous Atlantic area. *J. Mar. Biol. Assoc. UK.* 90(8): 1589–1599. <https://doi.org/10.1017/S0025315410000342>
- Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L., & Thomas, L. (2001). *Introduction to Distance Sampling*. Oxford University Press.
- Dalpaz, L., Paro, A.D., Daura-Jorge, F.G., Rossi-Santos, M., Norris, T.F., Ingram, S.N., & Wedekin, L.L. (2021). Better together: analysis of integrated acoustic and visual methods when surveying a cetacean community. *Mar. Ecol. Prog. Ser.* 678: 197–209. <https://doi.org/10.3354/meps13898>
- Gallo, A., De Moura Lima, A., Böye, M., Hausberger, M., & Lemasson, A. (2023). Study of repertoire use reveals unexpected context-dependent vocalizations in bottlenose dolphins (*Tursiops truncatus*). *Sci. Nat.* 110(6): 56. <https://doi.org/10.1007/s00114-023-01884-3>
- Gerrodette, T., Perryman, W., & Barlow, J. (2002). Calibrating group size estimates of dolphins in the eastern tropical pacific ocean. NOAA, Southwest Fisheries Science Center Administrative report LJ-02-08. La Jolla, California, USA.
- Gerrodette, T., Perryman, W.L., & Oedekoven, C.S. (2019). Accuracy and precision of dolphin group size estimates. *Mar. Mammal Sci.* 35(1): 22–39. <https://doi.org/10.1111/mms.12506>

⁵ <https://accurate.st-andrews.ac.uk/>

- Gerrodette, T., Taylor, B.L., Swift, R., Rankin, S., Jaramillo-Legorreta, A.M., & Rojas-Bracho, L. (2011). A combined visual and acoustic estimate of 2008 abundance, and change in abundance since 1997, for the vaquita, *Phocoena sinus*. *Mar. Mammal Sci.* 27(2). <https://doi.org/10.1111/j.1748-7692.2010.00438.x>
- Gillespie, D., Mchugh, R., McLaren, D., Mellinger, D.K., Redmond, P., Trinder, P., Deng, X.Y., & Thode, A. (2008). PAMGUARD: semiautomated, open source software for real-time acoustic detection and localisation of cetaceans. *J. Acoust. Soc. Am.* 125: 2547. <https://doi.org/10.1121/1.4808713>
- Gregg, J.D., Dudzinski, K.M., & Smith, H.V. (2007). Do dolphins eavesdrop on the echolocation signals of conspecifics? *Int. J. Comp. Psych.* 20(1). <https://doi.org/10.46867/ijcp.2007.20.01.01>
- Henderson, E.E., Hildebrand, J.A., Smith, M.H., & Falcone, E.A. (2011). The behavioral context of common dolphin (*Delphinus* sp.) vocalizations. *Mar. Mammal Sci.* 28(3): 439–460. <https://doi.org/10.1111/j.1748-7692.2011.00498.x>
- Jacobson, E.K., Forney, K.A., & Barlow, J. (2017). Using paired visual and passive acoustic surveys to estimate passive acoustic detection parameters for harbor porpoise abundance estimates. *J. Acoust. Soc. Am.* 141(1): 219. <https://doi.org/10.1121/1.4973415>
- Janik, V.M. (2000). Source levels and the estimated active space of bottlenose dolphin (*Tursiops truncatus*) whistles in the moray firth, Scotland. *J. Comp. Phys.* 186(7–8): 673–680. <https://doi.org/10.1007/s003590000120>
- Jefferson, T.A., & Rick, L. (2018). Delphinids, overview. In B. Würsig, J. G. M. Thewissen & K. M. Kovacs (Eds.) *Encyclopedia of Marine Mammals* (Third Edition, pp. 242–246). Academic Press.
- Jensen, F.H., Rocco, A., Mansur, R.M., Smith, B.D., Janik, V.M., & Madsen, P.T. (2013). Clicking in shallow rivers: Short-range echolocation of Irrawaddy and Ganges river dolphins in a shallow, acoustically complex habitat. *PLOS ONE* 8(4): e59284. <https://doi.org/10.1371/journal.pone.0059284>
- Jones, G.J., & Sayigh, L.S. (2002). Geographic variation in rates of vocal production of free-ranging bottlenose dolphins. *Mar. Mammal Sci.* 18(2): 374–393. <https://doi.org/10.1111/j.1748-7692.2002.tb01044.x>
- Krause, J., & Ruxton, G.D. (2002). *Living in Groups*. Oxford University Press. <https://doi.org/10.1093/oso/9780198508175.001.0001>
- Marques, F., & Buckland, S.T. (2004). Covariate models for the detection function. In S.T. Buckland, D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers, & L. Thomas (Eds.) *Advanced Distance Sampling: Estimating Abundance of Biological Populations* (pp.31–47). New York: Oxford University Press.
- Marques, T.A., Thomas, L., Martin, S.W., Mellinger, D.K., Ward, J.A., Moretti, D.J., Harris, D., & Tyack, P.L. (2013). Estimating animal population density using passive acoustics. *Biol. Rev.* 88(2): 287–309. <https://doi.org/10.1111/BRV.12001>
- Marques, T.A., Thomas, L., Ward, J., DiMarzio, N., & Tyack, P.L. (2009). Estimating cetacean population density using fixed passive acoustic sensors: an example with Blainville’s beaked whales. *J. Acoust. Soc. Am.* 125(4): 1982–1994. <https://doi.org/10.1121/1.3089590>
- Martin, M.J., Gridley, T., Roux, J.P., & Elwen, S.H. (2020). First abundance estimates of Heaviside’s (*Cephalorhynchus heavisidii*) and dusky (*Lagenorhynchus obscurus*) dolphins off namibia using a novel visual and acoustic line transect survey. *Front. Mar. Sci.* 7. <https://doi.org/10.3389/fmars.2020.555659>
- Mellinger, D.K., Stafford, K.M., Moore, S.E., Dziak, R.P., & Matsumoto, H. (2007). An overview of fixed passive acoustic observation methods for cetaceans. *Oceanography* 20(4): 36–45.
- Ollier, C., Sinn, I., Boisseau, O., Ridoux, V., & Virgili, A. (2023). Matching visual and acoustic events to estimate detection probability for small cetaceans in the ACCOBAMS Survey Initiative. *Front. Mar. Sci.* 10: 1244474. <https://doi.org/10.3389/fmars.2023.1244474>
- Panigada, S., Pierantonio, N., Araujo, H., David, L., Di-Méglio, N., Dorémus, G., Gonzalvo, J., Laran, S., Lauriano, G., Paiu, R.-M., Perri, M., Popov, D., Ridoux, V., Vázquez, J.A., & Cañadas, A. (2024). The ACCOBAMS Survey Initiative (ASI): The first synoptic assessment of cetacean abundance in the mediterranean sea through aerial surveys. *Front. Mar. Sci.* 10. <https://doi.org/10.3389/fmars.2023.1270513>
- R Core Team (2023). R: A language and environment for statistical computing. Foundation for Statistical Computing, Vienna, Austria.
- Rankin, S., Oedekoven, C., & Archer, F. (2020). Mark recapture distance sampling: using acoustics to estimate the fraction of dolphins missed by observers during shipboard line-transect surveys. *Environ. Ecol. Stat.* 27(2): 233–251. <https://doi.org/10.1007/s10651-020-00443-7>
- Richman, N.I., Gibbons, J.M., Turvey, S.T., Akamatsu, T., Ahmed, B., Mahabub, E., Smith, B.D., & Jones, J.P.G. (2014). To see or not to see: investigating detectability of Ganges river dolphins using a combined visual-acoustic survey. *PLoS ONE* 9(5). <https://doi.org/10.1371/journal.pone.0096811>
- Scheidat, M., Gilles, A., Kock, K., & Siebert, U. (2008). Harbour porpoise *Phocoena phocoena* abundance in the southwestern baltic Sea. *Endanger. Species Res.* 5: 215–223. <https://doi.org/10.3354/esr00161>
- Sinha, R.K., & Kannan, K. (2014). Ganges river dolphin: an overview of biology, ecology, and conservation status in India. *AMBIO* 43(8): 1029–1046. <https://doi.org/10.1007/s13280-014-0534-7>
- Soldevilla, M.S., Henderson, E.E., Campbell, G.S., Wiggins, S.M., Hildebrand, J.A., & Roch, M.A. (2008). Classification of Risso’s and Pacific white-sided dolphins using spectral properties of echolocation clicks. *J. Acoust. Soc. Am.* 124(1): 609–624. <https://doi.org/10.1121/1.2932059>
- Van Parijs, S.M., Smith, J., & Corkeron, P.J. (2002). Using calls to estimate the abundance of inshore dolphins: a case study with pacific humpback dolphins *Sousa chinensis*. *J. Appl. Ecol.* 39(5): 853–864. <https://doi.org/10.1046/j.1365-2664.2002.00756.x>