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ANIMAL PRODUCTION

Viability the use of drone applied in the mapping of artisanal commercial fisheries: A case study in Sepetiba Bay, Rio de Janeiro

Kátia Alessandra Mendes da Silva[1*] Luis Felipe Barbosa Braga Feitoza[2] Iane Silva Pereira[3] Silvia Conceição Reis Pereira Mello[4] Alessandra Carreiro Baptista[3] Gesilene Mendonça de Oliveira[5]

[1]Departamento de Tecnologia de Alimentos, Universidade Federal Rural do Rio de Janeiro (UFRRJ), 23890-000, Seropédica, RJ, Brasil. E-mail: kanutmendes@gmail.com. *Corresponding author.
[2]Animal Science & Industry Department, Kansas State University, Manhattan, KS, United States of America.
[3]Departamento de Engenharia, Universidade Federal Rural do Rio de Janeiro (UFRRJ), Seropédica, RJ, Brasil.
[4]Fundação Instituto de Pesca do Estado do Rio de Janeiro (FIPERJ), Rio de Janeiro, RJ, Brasil.
[5]Departamento de Tecnologia de Alimentos, Universidade Federal Rural do Rio de Janeiro (UFRRJ), Seropédica, RJ, Brasil.

ABSTRACT: This article presents an experimental study to verify the feasibility of using the emerging UAV technology in the mapping of fishing grounds exploited by artisanal fishing in Sepetiba Bay, in the south of the state of Rio de Janeiro-Brazil, aiming to better understand the functionality and information generated by the equipment, and whether the data can help improve local fisheries management and also provide information for the implementation of simplified traceability for regional fish. The study area included four locations, Ilha da Madeira, Vila Geny, Coroa Grande and Ponte Preta, all located in Sepetiba Bay, located in the municipality of Itaguaí, in the southern region of the state of Rio de Janeiro. The aerial mapping was carried out in September, October and November 2017, between 10 am and 12 pm (GMT-3), employing a Phantom 3 Professional UAV (DJI, Shenzhen, China), Anac Brasil registration number PP-011092014. The onboard camera a DJI 4K Edition Sony Exmor R Model IMX117: 7.81mm equipped with a CMOS sensor dimension of 6.2 mm, 4000 x 3000 12 megapixel resolution, with an f/2.8 lens and field of view (FOV) of 94, having a focal length of 14mm. Images were collected perpendicularly to the main plan. Flight height was set at 80 m, flight speed was determined based on the overlap of 80%, dimension of area to be mapped, and battery life. Hence, the operator utilized a average flight speed of 25 km/h. ground sample distance (GSD) was 1.20 cm/px. and an overlap of 80% between images was established to avoid possible failures and orthomosaic information gaps. For each fishery mapped, standard software processing was carried out, which consists of: aligning the photos, creating a point cloud, creating a digital elevation model, and finally the orthomosaic itself. Once processed, the orthomosaics were exported from Agis Soft Photo Scan Professional to Google Earth (Google Inc.), where it is possible to make a more comprehensive assessment of fisheries in a much more practical and faster way. A total of four flights were carried out, one for each study area, averaging 10 minutes each. As a result, the technology proved to be viable to apply, since it made it possible to identify and map the areas defined for this research, generating data such as distance and, characteristics of the place, which could be used to track the fish caught and landed, in addition to enabling the monitoring of vessels and fishing, and thus improve the management of local fisheries.
Key words: fish, artisanal fishing, aeromapping, remotely piloted aircraft, traceability.

Viabilidade do uso de drone aplicado no mapeamento da pesca artesanal comercial: um estudo de caso na Baía de Sepetiba, Rio de Janeiro

RESUMO: Este artigo apresenta um estudo experimental para verificar a viabilidade de uso da tecnologia emergente UAV no mapeamento dos pesqueiros explotados pela pesca artesanal na Baía de Sepetiba, no sul do estado do Rio de Janeiro-Brasil, visando conhecer melhor a funcionalidade e informações geradas pelo equipamento, e se os dados poderão auxiliar na melhoria do gerenciamento da pesca local e também subsidiar informações para a implantação de uma rastreabilidade simplificada para o pescado regional. A área de estudo contemplou quatro localidades sendo Ilha da Madeira, Vila Geny, Coroa Grande e Ponte Preta, todas inseridas na Baía de Sepetiba, localizada no município de Itaguaí, região sul do estado do Rio de Janeiro. O mapeamento aéreo foi realizado nos meses de setembro, outubro e novembro de 2017, entre 10h e 12h (GMT-3), utilizando um VANT Phantom 3 Professional (DJI, Shenzhen, China), registro Anac Brasil PP-011092014. A câmera integrada é uma DJI 4K Edition Sony Exmor R Modelo IMX117: 7,81 mm equipada com sensor CMOS de 6,2 mm, resolução 4000 x 3000 de 12 megapixels, com lente f/2.8 e campo de visão (FOV) de 94, possuindo uma distância focal de 14 mm. As imagens foram coletadas perpendicularmente ao plano principal. A altura de voo foi fixada em 80 m, a velocidade de voo foi determinada com base na sobreposição de 80%, dimensão da área a ser mapeada e duração da bateria. Assim, o operador utilizou uma velocidade média de voo de 25 km/h. a distância da amostra terrestre (GSD) foi de 1,20 cm/px. e foi estabelecida uma sobreposição de 80% entre as imagens para evitar possíveis falhas e lacunas de informações do ortomosaico. Para cada pesqueiro mapeado foi realizado o processamento padrão do software, que consiste em: alinhamento das fotos, criação da nuvem de pontos, criação de modelo de elevação digital, e finalmente o ortomosaico propriamente dito. Uma vez processado, os ortomosaicos foram exportados do Agis Soft Photo Scan Professional para o Google Earth (Google Inc.), onde é possível fazer uma avaliação mais abrangente dos pesqueiros de uma maneira muito mais prática e rápida. Foram realizados um total de quatro voos, um para cada área de estudo, com duração média de 10 minutos cada. Como resultado, a tecnologia mostrou-se viável de aplicação, uma vez que possibilitou identificar e mapear as áreas definidas para nesta pesquisa, gerando dados como distância e características do local, que poderão ser utilizados para rastrear o pescado capturado e desembarcado, além de possibilitar o monitoramento das embarcações e da pesca e assim, aprimorar o gerenciamento da pesca local.
Palavras-chave: pescado, pesca artesanal, aeromapeamento, remotely piloted aircraf, rastrabilidade.

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INTRODUCTION

The use of the emerging technology known worldwide as Unmanned Aerial Vehicles (UAV) and popularly called drones, has increasingly gained notoriety in the Fisheries Science field, mainly in large-scale commercial fishing, as drones allow for the use of aerial image data to define and implement appropriate management decisions in different aquatic ecosystems. Allied to these applications, this equipment can reach unhealthy or dangerous places for humans and is used in risky activities, such as delivering medicines to hostile areas or regions contaminated by radiation or under unfavorable weather conditions (CAI et al., 2010; ROSA et al., 2016). Furthermore, UAV do not suffer from cold or hunger, do not require clothes or training and can be updated through software. They do; however, require qualified personnel for operation (LUZ & ANTUNES, 2015; BHARDWAJ, 2016), in addition to exhibiting certain limitations regulated by unfavorable natural conditions, such as rain, wind and excess birds. However, even with these potential adversities, when employed under good planning and careful observations, UAV become a very efficient and safe tool (SANTOS, 2016).

Numerous activities involve the use of drones, including mapping and monitoring in the quantification of fishing efforts and their interaction with habitats, aiming cost reductions in operations involving the search for highly valuable fish, such as tuna. Drones are also applied in marine litter monitoring and in assessing changes in the migratory routes of different fish species, as well as in the inspection of illegal and incidental fishing, of employed fishing tools and of permanent protection areas and, finally, as a support for the fish traceability process (AUSTIN, 2010; KHAN, 2015; ZANETI et al., 2016; ATOLE et al., 2017; GIRARD & DU PAYRAT, 2017; DECEA, 2018).

Among others activities involving the use of drones there are the identification and accuracy in countinhg vessels tehri fishing equipamento and gear, more agility, less time for data collection (REIS-FILHO & GIARRIZZO, 2022), mapping fishing areas and the displacement of vessels (REIS-FILHO et al., 2022), and also increasing traditional artisan fishing management such as landing monitoring, eletronic logbooks and dealer reports (REIS-FILHO & GIARRIZZO, 2021).

The presence of the Sepetiba Bay watershed allows artisanal fishers to use this water body as an important source of food, work, and income. According to reports released by the Fishing Activity Monitoring Project in the State of Rio de Janeiro (PMAP-RJ), the sum of artisanal fish catches only for the second half of 2018, 2019 and 2020 was of, respectively, 98,404.43 kg, 94,000.3 kg and 9,579.2 kg (FIPERJ, 2019, 2020, 2021), indicating important fisheries contribution to the economic development of the city Itagauí, as well as to the food and nutritional security of the communities that live on the shores of the bay and the establishment of traditional populations in their place of origin, also contributing to social issues (job, incomea and local development); PACS, 2013; FIPERJ, 2019, 2020, 2021).

The use of UAV for fishing stock management is increasing in many coastal states worldwide and has become highly relevant as a new tool for obtaining fisheries data, as well as for the monitoring, surveillance and assessment of the environmental impacts caused by this practice and associated industrial developments. Artisanal fishing; however, is still not part of this scenario at a global level, due to certain limitations regarding equipment purchase and operationalization costs, as well as the demands of complex data, which must be processed and interpreted, the significant challenges in sharing this data between fisheries management authorities (governmental and non-governmental) and the limited number of individuals trained to use these tools (GIRARD & DU PAYRAT, 2017; COLLINS et al., 2017). This has generated the need for personnel training to allow for the operationalization of this technology to become, in fact, an ally in control activities.

Considering the possibilities presented trough the use of the UAV, the present study verified the viability of georeferencing the fishing areas, informed by the fishermen of the fishing communities located in the in the Sepetiba Bay, in municipality of Itaguaí, southern of the state of Rio de Janeiro, and beyond its use to assist in the process of identifying exploited fisheries, and will provide subsides for the creation of an effective traceability system based on this emergent technologies, contributing to the sustainable management of fishing activities benefiting fishermen, consumers and the local region, and contributing to decision-making, based on the collected data, by local authorities on the conservation and management of fishing resources.

MATERIALS AND METHODS

Considering the geological geological-geomorphological aspects, the hydrographic basin of Sepetiba Bay presents two distinct physiographic sets, with the mountainous domain represented by mountains and cliffs of the oceanic slope of Serra do Mar, coastal massifs (Pedra Branca, Mendanha, Ilha da Marambaia); and the domain of the lowlands, represented by an extensive river-marine plain, crossed by rivers that flow into Sepetiba Bay. The highest parts of the mountain domain (above 800m) are located in the Mazomba and Couto ranges (the SW and NE extremes of the area, respectively) and in the Tinguá, Mendanha, and Pedra Branca massifs. In the intermediate parts (200-400 and 400-600m) are located the valleys of the upper Rio Guandu (Serra das Araras) and Rio Santana, where the Serra do Mar presents a more dissected relief (SEMADS, 2001).

This study was carried out at the Ponte Preta (P1), Coroa Grande (P2), Vila Geny (P3) and Ilha da Madeira (P4) fishing communities, located in the municipality of Itaguaí (Figure 1).

The delimited area established for mapping artisanal fishing locations was defined in accordance with a 30-year experience fishermen information obtained through the fishing communities themselves and through field research, through the application of a semi-structured questionnaire, adapted from PIEVE et al. (2009), containing both open and closed questions. The questionnaire consisted of two parts, the first referring to the sociocultural profile of the interviewees and the second, to their fishing activity, thus defining the fishing spots. The sampling sites closest to the mainland are Coroa Grande (CG) and Ponta do Boi (PB), and the most distant, Saco da Pombeba (SP).

The aerial mapping was carried out in September, October and November 2017, between 10 am and 12 pm (GMT-3), employing a Phantom 3 Professional UAV (DJI, Shenzhen, China), Anac Brasil registration number PP-011092014. The onboard camera i a DJI 4K Edition Sony Exmor R Model IMX117: 7.81mm equipped with a CMOS sensor dimension of 6.2 mm, 4000 x 3000 12 megapixel resolution, with an f/2.8 lens and field of view (FOV) of 94, having a focal length of 14mm. Images were collected perpendicularly to the main plan.

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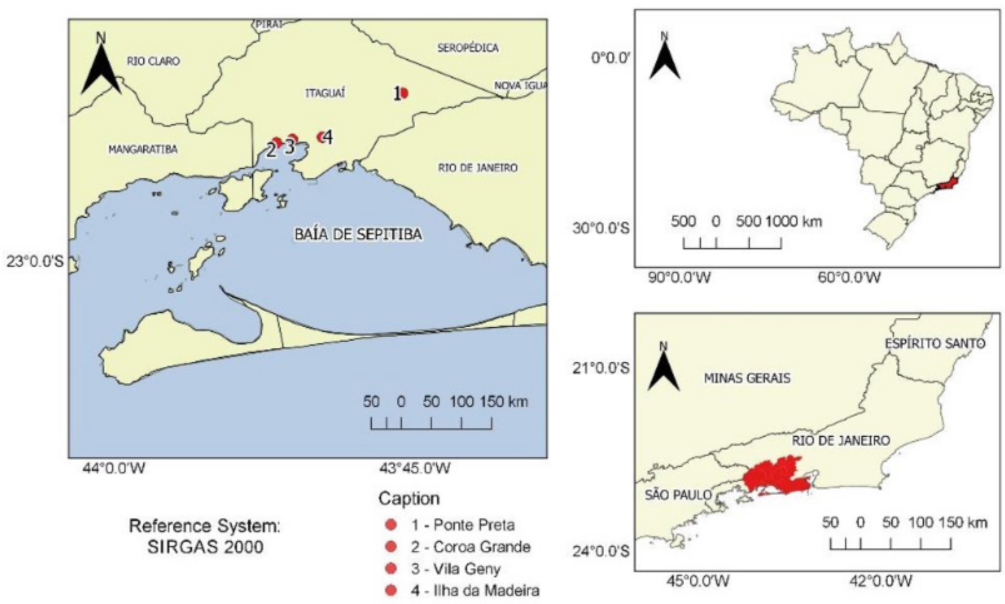

Figure 1 - Study area: Sepetiba Bay, Rio de Janeiro, Brazil. A circle indicated the location of fishing communities in the municipality of Itaguaí, RJ 1 - Ponte Preta fishing community of; 2 - Coroa Grande fishing community; 3 - Vila Geny fishing community of and 4 – Ilha da Madeira fishing community of. Source: Prepared by the authors of this manuscript according to 2018 research data.

were carried out, one for each study area, averaging 10 minutes each. The dimension of the scanned area was determined by live observation of the area being mapped, therefore, was not pre-determined at pre-flight planning. In nature of the artisanal fishing activities and lack of objective mapping data to be followed, the alternative was to use the over 30-year expertise of the fishermen and fishing communities to aid on the image collection of the areas.

Anac guidelines were applied for the aerial mapping, according to the Brazilian Regulation of Special Civil Aviation (RBAC - E) no. 94 UAV, with flights only performed at lower than 400 ft, with a 30 m distance from civilians and with the UAV always in sight (Visual Line-Of-Sight- Vlos operation). For additional security, the manufacturer's own operating system (DJI) detects prohibited flying areas, such as commercial flight routes and locations near airports and helipads. The employed UAV also has a safety equipment for the event of an adverse situation of signal loss between the ground controller and the equipment. In these cases, the aircraft returns to the starting takeoff point guided by the autopilot system.

Following collection, all images were downloaded to a computer, selected by deleting repeated and blurred photos and processed for orthomosaic compilation and formation using the Agis Soft Photoscan Professional software. This consists in the compilation of superimposed images by the Global Positioning System (GPS), correcting topographic distortions and generating a single image with the compiled data.

Standard software processing was performed for each mapped fishery location, aligning the photos and creating the point cloud, the digital elevation model and, finally, the orthomosaics. Once processed, the orthomosaics were exported to Google Earth (Google Inc.), where more comprehensive, practical and quick fisheries assessments were without the need for advanced techniques. Figure 2 presents the flowchart with the main data selection and processing steps from the UAV imaging.

In addition to considering the to the geological and geomorphological aspects, prior to the field trips, weather conditions were assessed through bulletins obtained from communication vehicles, allowing for mapping only in excellent weather conditions concerning wind, light and rain.

Fishing spots were reached by means of a small fiberglass 7.30 m boat powered by a 40.0 HP gasoline engine provided by the Municipal Department of Agriculture and Fisheries (Semap) of the municipality of Itaguaí, registered under the number 3830641095. It was produced in 2016 and can carry one crew member and nine passengers for both people and cargo transport.

The technical team launched the boat at the Ilha da Madeira Yacht Club, in Itaguaí, RJ, on September 28 to assess the Ponta do Boi and Rio da Guarda sampling sites, on October 5 to assess Saco de Coroa Grande and on November 02 to assess Saco da Pombeba. A navigation plan was filled out for each departure, numbered according to Yacht Club records, containing information on the crew, the number of people on board, boat engine type, survival

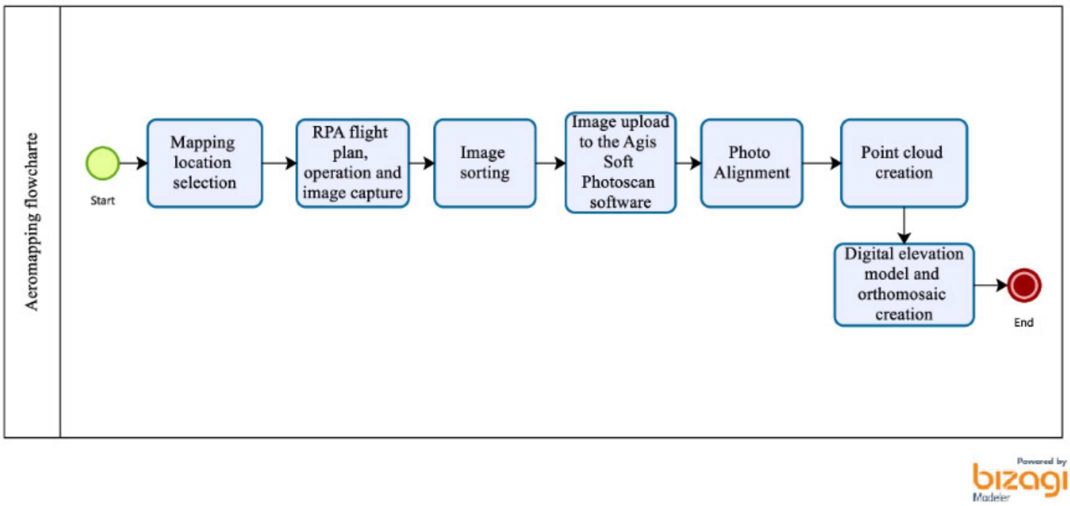

Figure 2 - Flowchart of the aerial mapping of fishing spots located in Sepetiba Bay, RJ. Source: 2018 survey data.

equipment, destination, probable date and time of departure and return. The vessel carried one crew member and three passengers (the vessel's assistant, the researcher, the UAV operator, and a collaborator from the Semap technical staff).

RESULTS AND DISCUSSION

The questionnaire was approved by the Committee of Ethics of the Universidade Federal Rural do Rio de Janeiro (UFRRJ) under the ID number 23083.014072/2017. To complement the questionnaire, the participatory observation technique was used in order to establish direct contact with the artisanal fishermen and to learn about their routines/daily activities.

The total number was 33 fishermen interviewed, nine (9) from Ponte Preta, fourteen (14) from Madeira Island, five (5) from Coroa Grande and five (5) from Vila Geny where the average age was 44 years, of the fishermen handicrafts, low level of education (incomplete secondary education), 90% male, 60% married, 94% have their own home, 43% have other activities such as mason and boat driver.

Fishing on the studied areas is characterized by small vessels manufactured by the fishermen themselves, with weekly departures and an average duration of 8 to 15 days. The most captured species are mullet, croaker, true sardines and gray shrimp because they have greater commercial value.

Fishing spot aeromapping

The fishing areas used by artisanal fishers comprised Vila Geny (A) 94,321 m2 acquired foot-print dimension, Coroa Grande (B); 70,130 m2 acquired foot-print dimension, Ilha da Madeira (C); 65,128 m2 acquired foot-print dimension, Ponta do Boi (D); 100,320 m2 acquired foot-print dimension and Saco da Pombeba (E); 38,822 m2 acquired foot-print dimension. Figure 3 exhibits the aerial orthomosaic map of each location.

Orthomosaics A, B, C and D indicate a residential and industrial urban zoning bordering the fishing areas, indicating the importance of an effective fishing system aiming fishers as a result of existing conflicts concerning dispute over territories, where the surroundings industries demarcate the areas of distance for the fishermen, ensuring their safety between their operations and their large vessels, which would also allow fishing culture and tradition maintenance over future generations.

Orthomosaic D indicates the Guarda River, which allows fisher access from Ponte Preta to Sepetiba Bay, reaching the same fishing areas. This river; however, requires occasional dredging due to aquatic plant proliferation, making it difficult for small boats to move and; therefore, for fishers to leave. Semap technical staff; however, has provided all the necessary assistance so that fishing is not interrupted in this community.

BEGOSSI (2004) defines the aquatic space used for fishing by several individuals or by an entire community as a fishing area, with specific fishing areas, also termed micro-areas. Based on these definitions, this study employs only the term fishing area, since local artisanal fishers do not present specific fishing points, moving according to fish shoal location.

UAV have been employed to obtain high resolution images in different scenarios, seeking to see beyond human eyes. ATOLE et al. (2017), for example, employed this technology to observe fish behavior and examine regional topographies to identify aerial territory coverage. In another study, TYLER et al. (2018) applied UAV to carry out a freshwater fish census, obtaining data on fish sex, age and size, while CHRISTIE et al. (2016) reviewed how the use of this technology interferes with wild fauna behavior, habitat and abundance.

GIRARD & DU PAYRAT (2017) emphasize that the use of this technology allows managers to obtain more information on fish stocks, to monitor, inspect and evaluate fishing activity impacts and improve the effectiveness of policies and decision-making for more sustainable fisheries management. In line with these authors, this study was able to identify not only the fishing areas used by the investigated communities, but also surrounding enterprises, which, in future research, may be applied to more precisely delimit the identified fishing areas.

The use of the Global Navigation Satellite System (GNSS), which, according to DECEA (2018), is defined by a constellation of satellites, including GPS, is available for mapping areas and fishing spots.

The Brazilian Navy has also carried out UAV assessments. For example, in 2014, this technology was used to monitor the Blue Amazon, comprising 3.6 million km² of expressive marine biodiversity along the entire Brazilian coast (CONSTÂNCIO, 2014). In another assessment, PROVOST et al. (2020) indicated UAV as a tangible, easy-to-implement tool that positively contributes to fisheries management improvement and sustainability when monitoring the use of illegal fishing traps to capture crabs in small estuaries. The WAITT INSTITUTE (2014) and TYLER et al. (2018) also carried out research corroborating the importance

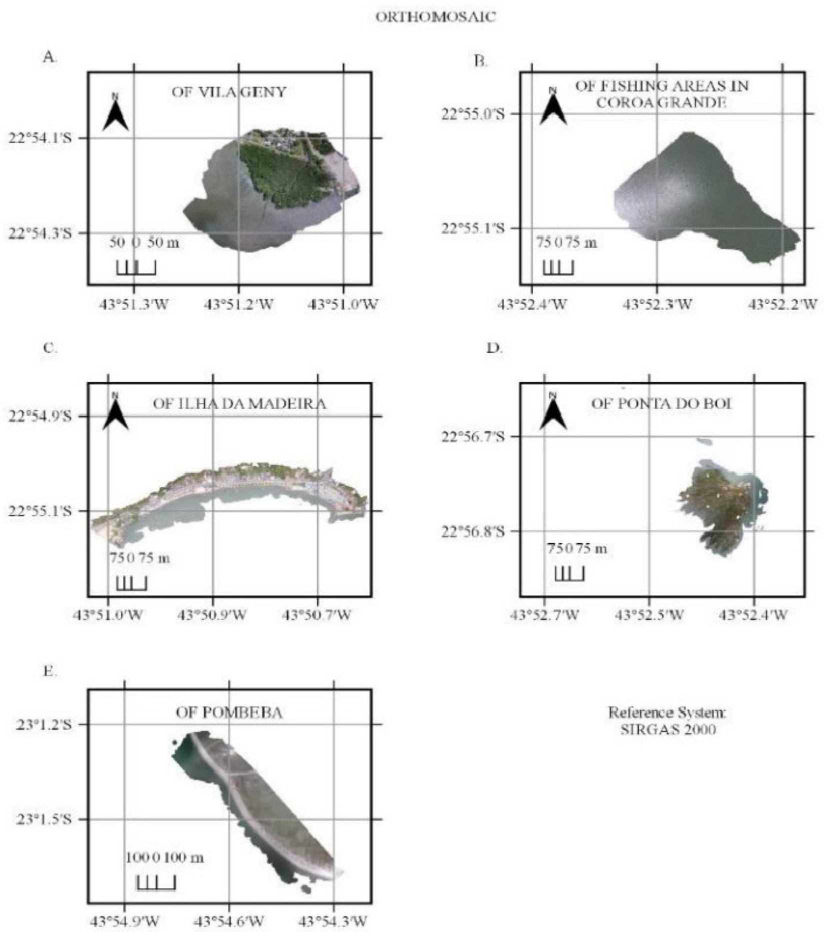

Figure 3 - Orthomosaic A: Aerial Orthomosaic map - Vila Geny. Orthomosaic B: Aerial orthomosaic map - Coroa Grande. Orthomosaic C: Aerial Orthomosaic map – Ilha da Madeira. Orthomosaic D: Aerial orthomosaic map - Ponta do Boi. Orthomosaic E: Aerial orthomosaic map - Pombeba. Source: 2018 survey data.

of this technology in several fishing assessments, reiterating its low costs in this regard.

Another highlight is the fact that the studied area is considered a nursery for aquatic organisms, and the UAV can increase the monitoring of species that develop there and help in decision-making to apply and guarantee aspects related to sustainability. Finally, there was a strong interest from fishermen to better understand the operation of the equipment and also great enthusiasm with the result of data collection, which demonstrates a good possibility of forming partnerships for greater use of UAV.

In addition to the possibilities presented above, it should be noted that the images generated by the UAV will allow monitoring the forms of aborge and the watchmen with the fishermen, the presence of large vessels, during the fishing period. Finally, the need for greater investments and control improvements in the communities studied is reinforced, aiming the growth, development and maintenance of fishing, as it is an ancestral activity that provides food.

CONCLUSION

The use of the UAV in this region proved to be feasible to identify and map the fishing areas, which will allow the improvement of fishing management, through the monitoring of the conditions of the vessels and fishing. This technology also makes it possible to envisage the implementation of a simplified traceability system, which can add value to the fish sold in the region. It is important to point out that the training regarding the operation of the UAV, as well as the knowledge of the geographic and climatic conditions are essential for the proper operation of the UAV.

DECLARATION OF CONFLICT OF INTEREST

We have no conflict of interest to declare.

AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version.

REFERENCES

ATOLE, R. R. et al. Eyes in the sky: a review of civilian unmanned aerial vehicles (UAVs). **Inter J Comp Applications**, v.173, n.6, p.36–41, 2017.

AUSTIN, R. Unmanned aircraft systems: UAVs design, development and deployment. **Chippenham** (Wiltshire/UK): A John Wiley and Sons, Ltd, 2010.

BEGOSSI, A. **Áreas, pontos de pesca, pesqueiros e territórios na pesca artesanal**. In: BEGOSSI, A. Ecologia de pescadores da mata atlântica e da Amazônia. São Paulo (São Paulo/Brasil): Hucitec. p.223–253,2004.

BERTRAM V. **Unmanned surface vehicles**: A survey. In: Skibsteknisk Selskab, Copenhagen, Denmark. p.1–14, 2008.

BHARDWAJ, A. et al. UAVs as remote sensing platform in glaciology: present applications and future prospects. **Remote Sensing of Environment**, v.175, p.196–204, 2016.

CAI, G et al. An overview on development of miniature unmanned rotorcraft systems. **Frontiers of Electrical and Electronic Engineering in China**, 2010.

CHRISTIE, K. et al. Unmanned aircraft systems in wildlife research: current and future applications of a transformative technology. **Frontiers in Ecology and the Environment**, v.14, n.5, p.241–251, 2016.

COLLINS, G. et al. Using vessel-based drones to aid commercial fishing operations. **Proc. OCEANS**. p.1–5. 2017.

CONSTÂNCIO, T. Marinha testa drone para patrulhar a Amazônia Azul. **Jornal O Estadão**, 2014. Available from: <http://politica.estadao.com.br/noticias/geral,marinha-testa-drone-para-patrulhar-a-amazonia-azul,1132006>. Accessed: Apr. 19, 2018.

DECEA - Departamento de Controle de Espaço Aéreo. **Drones (UAVS)**. Decea.2018. Available from: <https://www.decea.gov.br/drone>. Accessed: Ago. 6, 2018.

DOURADO, F. et al. 2012. Os novos empreendimentos e os passivos ambientais industriais na baía de Sepetiba. In: Rodrigues, M. et al. **Baía de Sepetiba**: Estado da Arte. Rio de Janeiro (Rio de Janeiro/Brasil): Editora Corbã. p.253–262. 2012.

FIPERJ - Fundação Instituto de Pesca do Estado do Rio de Janeiro. Projeto de Monitoramento da Atividade Pesqueira no Estado do Rio de Janeiro (PMAP-RJ). Relatório Técnico Semestral – RTS-03. 2019.

FIPERJ - Fundação Instituto de Pesca do Estado do Rio de Janeiro. 2020. Projeto de Monitoramento da Atividade Pesqueira no Estado do Rio de Janeiro (PMAP-RJ). Relatório Técnico Semestral – RTS-05. 2020.

FIPERJ - Fundação Instituto de Pesca do Estado do Rio de Janeiro. Projeto de Monitoramento da Atividade Pesqueira no Estado do Rio de Janeiro (PMAP-RJ). Relatório Técnico Semestral – RTS-01.2021.

GIRARD, P.; DU PAYRAT, T. An inventory of new technologies in fisheries. Issue Paper. Green Growth and Sustainable Development (GGSD) Forum. **Organization Economic Co-Operation and Development (OECD)**. 2017.

KHAN, I. Fishing in view: satellite technology based monitoring, control and surveillance system for Pakistan marine sector. **Workshop on the applications of global navigation sattelite system**. Krasnoyarsk-Russia. 2015.

LUZ, C. C.; ANTUNES, A. F. B. Use of UAV Technology to Update Geological Cartographic Databases – Case Study: Karst System João Rodrigues River **Rev Bras Cart**, v.67, n.7, p.1439–1452. 2015.

PACS. Instituto Políticas Alternativas para o Cone Sul. **Baía de Sepetiba**: fronteira do desenvolvimentismo e os limites para a construção de alternativas. 2013. 126p. ISBN 978-85-89366-31-1.

PIEVE, S. M. N. et al. **Pescadores da Lagoa Mirim etnoecologia e resiliência**. Brasília (Distrito Federal/Brasil): MDA. 2009.

PROVOST, E. J. et al. Aerial drone technology can assist compliance of trap fisheries. **Fish Manag Ecol**, v.27, n.4, p.381–388. 2020.

REIS-FILHO, J. A.; GIARRIZZO, T. Perspectives on the use of unmanned aerial vehicle systems as tools for small-scale. fisheries research and management. **Fisheries Magazine**, v.47, n.2, p.78-89. 2021. doi: 10.1002/fsh.10696.

REIS-FILHO, J. A. et al. The challenges and opportunities of using small drones to monitor fishing activities in a marine protected área. **Fisheries Management and Ecology**, v.29, n.5, p.745-752. 2022. doi: 10.1111/fme.12557.

REIS-FILHO, J. A.; GIARRIZZO, T. Drone surveys are more efficient and cost effective than ground- and boat-based surveys for the inspection of fishing fleet at harbors. **Coasts**, 2(4), p.355-368. 2022. doi: 10.3390/coasts2040018.

ROSA, G. D. C. et al. Unmanned Aerial Vehicles in the Navy: its benefits, **Sci Bull Nav Acad**, v.19, n.1, p.39–43.2016.

SEMADS. **Secretaria de Estado de Meio Ambiente e Desenvolvimento Sustentável**. Bacias Hidrográficas e Recursos Hídricos da Macrorregião Ambiental 2 - Bacia da Baía de Sepetiba: Rio de Janeiro. 2001. 79p. ISBN 85-87206-07-9.

TYLER, S. et al. Perspectives on the application unmanned aircraft for freshwater for fisheries census. **Fish Mag**, v.43, n.11, p.510–516. 2018.

ZANETTI, J. et al. Influence of number and distribution of control Points on orthophotos generated from a UAV survey. **Rev Bras Cart**, v.69, n.2, p.263–277. 2017.