DOI https://doi.org/10.34331/cpops.2022O001 J-STAGE Advance published date: June 9, 2023

Short Communication

DEVELOPMENT PROGRESS OF A LONG-RANGE VERTICAL TAKEOFF AND LANDING UAV FOR THE IMPROVEMENT OF SHIP-BASED CETACEAN SIGHTING SURVEYS

Taiki KATSUMATA* and Takashi YOSHIDA

Institute of Cetacean Research, 4–5 Toyomi-cho, Chuo-ku, Tokyo 104–0055, Japan
**Corresponding author: katsumata@cetacean.jp*

Key words: aerial survey, cetacean, drone, unmanned aircraft systems, unmanned aerial vehicle, VTOL-UAV/ASUKA.

Estimating the abundance of cetaceans is critical to the conservation and management of those species concerned. Abundance estimates are based primarily on sighting data collected during shipboard sighting surveys. However, these useful and standardized survey methods have their limitations. In some cases, surveys may not be able to entirely cover the cetacean distribution areas, such as coastal areas with high density of fishing gear, or pack ice areas in polar regions. To improve the abundance estimates in such undersurveyed areas, in 2019 we started developing an unmanned aerial vehicle (UAV) which was subsequently given the name of ASUKA (Matsuoka and Yoshida, 2021). The new aircraft would have to combine the following four characteristics. First, be able to takeoff and land vertically, allowing deployement from and to confined spaces on the research ship's deck. Second, be able of long flight time required to cover large survey areas. Third, be able to carry sufficient payload for installing a camera or cameras, which can capture a wide range with a high resolution to detect and identify cetacean species. The final point is the UAV's resistance to windy conditions. Because cetacean sighting surveys are conducted offshore, an aircraft that can operate in windy conditions is required.

After repeated trials with flight tests at sea in 2019 and 2020, the ASUKA Mk 4 was completed in 2021. In March 2021, ASUKA Mk 4 achieved an autonomous flight distance of 51 km from a research vessel in the North Pacific. Then, in March 2022, it autonomously flew 104 km in 1 hour and 20 minutes at an altitude of approximately 110 m, setting a new Japanese record for distance traveled in a single flight by a small UAV (Fig. 1). In addition, a preliminary fin whale (*Balaenoptera physalus*) field survey off Abashiri, Hokkaido (Fig. 2) and another for finless porpoise (*Neophocaena sunameri*) in Mikawa Bay, Aichi, were conducted. Equipped with a Sony DSC-RX0M2 camera, ASUKA Mk 4 successfully detected both target species. In the near future, the ASUKA Mk 5 (Fig. 3 and Table 1), developed as a commercial model, will be used in actual whale research in the Antarctic Ocean to conduct aerial visual surveys in areas of pack ice where vessels cannot navigate.

UAVs are increasingly being used to observe and study marine mammals, including cetaceans. A Google Scholar search (https://scholar.google.com) on the number of articles containing "UAVs" and "marine mammals" showed that it quadrupled from 2012 to 2021. In addition to visual surveys of marine mammals, UAVs have been used for photogrammetry, photo ID, and tagging (Leslie *et al.*, 2020; Ryan *et al.*, 2022; Murakami *et al.*, 2021). This suggests that UAVs are replacing helicopters and small aircraft that require airfields for takeoff and landing, and that UAVs are becoming a necessary survey tool. Cetacean research using UAVs has already begun (e.g., Hodgson *et al.*, 2017), and they are being used for various observational purposes in polar regions (e.g., Funaki *et al.*, 2014; Angliss *et*

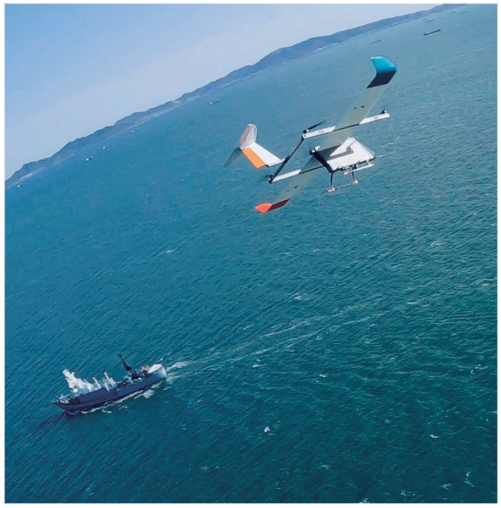

Fig. 1. VTOL-ASUKA (Mk 4 Type 2) during vertical take-off from the research vessel in Mikawa Bay on 27 March 2022.

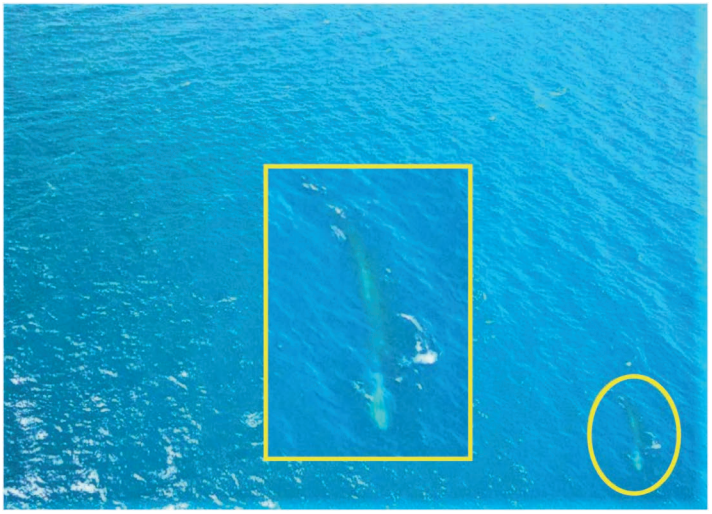

Fig. 2. An underwater fin whale photograph taken by ASUKA (Mk 4 Type 2) off Abashiri, Hokkaido, on 27 May 2022. The approximate flying altitude was 80 m.

Fig. 3. The latest VTOL-UAV aircraft (ASUKA Mk 5) developed in 2022.

Table 1. Specification of the newly-developed VTOL-UAV in 2022.

Item	ASUKA Mk 5*
Overall length	1,904 mm
Wingspan	3,335 mm
Overall height	843 mm
Body weight	22.9 kg
Cruising range	Over 100 km
Maximum speed	160 km/h (Long-range flight cruising speed 80 km/h)
Payload	5 kg maximum (104 km range achieved with a 2 kg payload)
Seaworthiness	Regular operation at 25-knot wind speed Level flight maintained at 40-knot wind speed

*The acronym 'Mk' and 'Type' followed by a number indicate the UAV prototype series identifier.

al., 2018). In addition, in anticipation of the widespread use of UAVs, methods have been developed for abundance estimation using digital data captured by cameras (Borchers *et al.*, 2020). Given the above, it is highly probable that abundance estimation of marine mammals using data obtained with UAVs will become more widespread. Accordingly, we anticipate that ASUKA, which can take off from and land on a ship and has a long-range, and sufficient payload capacity, will be used in visual and various other surveys.

Acknowledgements

We thank the Fisheries Agency of Japan for granting research permits and funding for developing and implementing the UAV project. We also thank Drs. Hiroto Murase, Koji Matsuoka and Yoshihiro Fujise for their assistance with survey design and logistical support.

References

Angliss, R. P., Ferguson, M. C., Hall, P., Helker, V., Kennedy, A. and Sformo, T. 2018. Comparing manned to unmanned aerial surveys for cetacean monitoring in the Arctic: Methods and operational results. *J. Unmanned Veh. Sys.* 6(3): 109–127. doi: 10.1139/juvs-2018-0001.

Borchers, D. L., Nightingale, P., Stevenson, B. C. and Fewster, R. M. 2020. A latent capture history model for digital aerial surveys. *Biometrics* 78(1): 274–285. doi: 10.1111/biom.13403.

Funaki, M., Higashino, S.-I., Sakanaka, S., Iwata, N., Nakamura, N., Hirasawa, N., Obara, N. and Kuwabara, M. 2014. Small unmanned aerial vehicles for aeromagnetic surveys and their flights in the South Shetland Islands, Antarctica. *Polar Sci.* 8(4): 342–356. doi: 10.1016/j.polar.2014.07.001.

Hodgson, A., Peel, D. and Kelly, N. 2017. Unmanned aerial vehicles for surveying marine fauna: Assessing detection probability. *Ecol. Appl.* 27(4): 1253–1267. doi: 10.1002/eap.1519.

Matsuoka, K. and Yoshida, T. 2021. Geirui shigen chousa ni mochiiru doron (mujin koukuuki: UAV) no Kaihatsu (Development of drones (unmanned aerial vehicles-UAV) for whale research). *Geiken Tsuushin* 491: 1–8. (In Japanese).

Leslie, M., Perkins-Taylor, C., Durban, J., Moore, M., Miller, C., Chanarat, P., Bahamonde, P., Chiang, G. and Apprill, A. 2020. Body size data collected non-invasively from drone images indicate a morphologically distinct Chilean blue whale (*Balaenoptera musculus*) taxon. *Endanger. Species Res.* 43: 291–304. doi: 10.3354/esr01066.

Murakami, R., Toyoshima, T., Furusawa, D., Suzuki, M., Masumoto, K., Owada, S., Tsumaki, Y. and Mori, K. 2021. Logger attaching system for sperm whales using a drone. *J. Robot. Mechatron.* 33(3): 475–483. doi: 10.20965/jrm.2021.p0475.

Ryan, K. P., Ferguson, S. H., Koski, W. R., Young, B. G., Roth, J. D. and Watt, C. A. 2022. Use of drones for the creation and development of a photographic identification catalogue for an endangered whale population. *Arct. Sci*. 8(4): 1191–1201. doi: 10.1139/as-2021-0047.

Received: November 26, 2022
Published online: June 9, 2023