**APPENDIX**

**LITERATURE SEARCH**

**Table A1.** Final dataset generated from literature search for studies using drones to monitor/research seabirds. This yielded 114 relevant studies summarised below in chronological order.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Title** | **Authors** | **Year** | **Aim** | **Seabird species** | **Life-history stage** | **Assemblage** | **Drone type** | **Engine** | **Analysis method** | **Present in disturbance table?** | **Compared with traditional ground surveys?** | **Source** | **Notes** |
| Fine‐scale bird monitoring from light unmanned aircraft systems | Sardà‐Palomera, F., Bota, G., Viñolo, C., Pallarés, O., Sazatornil, V., Brotons, L., Gomáriz, S. & Sardà, F. | 2012 | Abundance | Black-headed Gull *Chroicocephalus ridibundus* | Breeding | Colony | Fixed-wing | Fixed-wing, electric (Multiplex Twin Star II, HiTec/Multiplex) | Manual | Yes | No | Google scholar |  |
| UAS-based automatic bird count of a common gull colony | Grenzdörffer, G.J. | 2013 | Abundance | Common Gull *Larus canus* | Breeding | Colony | Multi-rotor | 4-copter, electric (MD 4 1000, Microdrones GmbH) & 8-copter (Falcon 8, Ascending Technologies) | Semi-automated | Yes | No | Google scholar |  |
| Testing marine conservation applications of unmanned aerial systems (UAS) in a remote marine protected area | Brooke, S; Graham, D; Jacobs, T; Littnan, C; Manuel, M; O'Conner, R | 2015 | Detection | Black-footed Albatross *Phoebastria nigripes*, Laysan Albatross *Phoebastria immutabilis*, Great Frigatebird *Fregata minor*, Red-footed Booby *Sula sula* | Breeding | Colony | Fixed-wing | Fixed-wing, electric (Puma All-Environment) | Manual | No | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured, as seabirds counted post-analysis as an 'after-thought' |
| Population Census of a Large Common Tern Colony with a Small Unmanned Aircraft | Chabot, D; Craik, SR; Bird, DM | 2015 | Abundance | Common Tern *Sterna hirundo* | Breeding | Colony | Fixed-wing | Fixed-wing, electric (AI-Multi UAS, Aerial Insight) | Manual | Yes | Yes | Web of science/Scopus |  |
| Kite aerial photography: A low-cost method for monitoring seabird colonies | Delord K., Roudaut G., Guinet C., Barbraud C., Bertrand S., Weimerskirch H. | 2015 | Abundance | Guanay Cormorant *Phalacrocorax bougainvillii*, Macaroni Penguin *Eudyptes chrysocome*, King Penguin *Aptedonytes patagonicus* | Breeding | Colony | Kite | Guanay cormorants: Canon Powershot G11 carried on the string of a single-line rokkaku kite using Picavet suspension rig. King Penguin: Ricoh IV GR carried on string of single-line delta kite with a home-made tilting platform T-suspension system. Macaroni Penguin: GoPro Hero 3 carried on string of single-line delta kite with a home-made tilting platform T-suspension system | Manual | Yes | No | Web of science/Scopus |  |
| Evaluation of an unmanned rotorcraft to monitor wintering waterbirds and coastal habitats in British Columbia, Canada | Drever, MC; Chabot, D; O'Hara, PD; Thomas, JD; Breault, A; Millikin, RL | 2015 | Abundance | Seabirds' including Marbled Murrelet *Brachyramphus marmoratus*, Mew Gull *Larus canus*, Ring-billed Gull *Larus delawarensis* | Foraging | Individuals/groups | Helicopter UAS | Single rotor helicopter, electric (Responder, ING Robotic Aviation) | Manual | No | No | Web of science/Scopus | Not included in disturbance table: disturbance measured for 'waterbirds' generally, but not recorded for specific families/species of waterbird. Decoy Surf Scoters were used to assess minimum resolution to identify waterfowl species, suggesting Surf Scoters were present in surveys, but this is not confirmed. |
| Applications of Unmanned Aircraft Systems (UAS) for Waterbird Surveys | Dulava, S; Bean, WT; Richmond, OMW | 2015 | Detection, abundance, disturbance | Surf Scoter *Melanitta perspicillata* | Non-breeding | Individuals/groups | Fixed-wing | Fixed-wing, gas-powered (Honeywell RQ-16 |  |  |  | Web of science/Scopus | Not included in disturbance table: disturbance measured for 'seabirds' generally, but not recorded for specific families/species of seabird |
| A small unmanned aerial system for estimating abundance and size of Antarctic predators | Goebel M.E., Perryman W.L., Hinke J.T., Krause D.J., Hann N.A., Gardner S., LeRoi D.J. | 2015 | Abundance | Chinstrap Penguin *Pygoscelis antarctica*, Gentoo Penguin *Pygoscelis papua* | Breeding | Colony | Multi-rotor | T-Hawk and fixed-wing, electric (AeroVironment RQ-11A)" | Manual | No | No | Web of science/Scopus |  |
| A protocol for the aerial survey of penguin colonies using UAVs | Ratcliffe, N; Guihen, D; Robst, J; Crofts, S; Stanworth, A; Enderlein, P | 2015 | Protocol | Gentoo Penguin *Pygoscelis papua*, King Penguin *Aptenodytes patagonicus* | Breeding | Colony | Multi-rotor | 8-copter, electric (HiSystems, MK ARF Okto XL) | Manual | Yes | Yes | Web of science/Scopus | Analysis type is NA because images were not analysed |
| Indicator species population monitoring in Antarctica with UAV | Zmarz A., Korczak-Abshire M., Storvold R., Rodzewicz M., Kędzierska, I.. | 2015 | Abundance | Adélie Penguin *Pygoscelis adeliae*, Chinstrap Penguin *Pygoscelis antarcticus*, Gentoo Penguin *Pygoscelis papua* | Breeding | Colony | Fixed-wing | Not recorded | NA | Yes | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Preliminary study on nesting Adelie penguins disturbance by unmanned aerial vehicles | Korczak-Abshire, M; Kidawa, A; Zmarz, A; Storvold, R; Karlsen, SR; Rodzewicz, M; Chwedorzewska, K; Znoj, A | 2016 | Disturbance | Adélie Penguin, *Pygoscelis adeliae* | Breeding | Colony | Fixed-wing | Fixed-wing, electric (PW-ZOOM) | Automated | No | No | Web of science/Scopus |  |
| RAPID POPULATION ESTIMATE OF A SURFACE-NESTING SEABIRD ON A REMOTE ISLAND USING A LOW-COST UNMANNED AERIAL VEHICLE | McClelland, GTW; Bond, AL; Sardana, A; Glass, T | 2016 | Abundance | Tristan Albatross *Diomedea dabbenena* | Breeding | Colony | Multi-rotor | Fixed-wing, electric (Skywalker X-8) | Manual | Yes | No | Web of science/Scopus |  |
| Measuring the influence of unmanned aerial vehicles on Ad,lie penguins | Rúmmler, MC; Mustafa, O; Maercker, J; Peter, HU; Esefeld, J | 2016 | Disturbance | Adélie Penguin, *Pygoscelis adeliae* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 2) | Manual | Yes | No | Web of science/Scopus |  |
| Precision wildlife monitoring using unmanned aerial vehicles | Hodgson, J.C., Baylis, S.M., Mott, R., Herrod, A. & Clarke, R.H. | 2016 | Abundance | Royal Penguin *Eudyptes schlegeli*, Crested Tern *Thalasseus bergii*, Lesser Frigatebird *Fregata ariel* | Breeding and Moulting | Colony | Fixed-wing and Multi-rotor | 8-copter, electric (HiSystems, MK ARF Okto XL) | Manual | Yes | No | Google scholar |  |
| Seabird species vary in behavioural response to drone census | Brisson-Curadeau É., Bird D., Burke C., Fifield D.A., Pace P., Sherley R.B., Elliott K.H. | 2017 | Abundance, disturbance | Iceland Gull *Larus glaucoides*, Glaucous Gull *Larus hyperboreus*, Herring Gull *Larus argentatus*, Thick-billed Murre *Uria lomvia*, Common Murre *Uria aalge* | Breeding and Non-breeding | Colony and Individuals | Multi-rotor | Fixed-wing (custom built with HornbillSurveys.com, FX79 airframe) and 8-copter, electric (X8 3D Robotics) | Manual | Yes | Yes | Web of science/Scopus | Compared with ground photography |
| Possibility of applying unmanned aerial vehicle (UAV) and mapping software for the monitoring of waterbirds and their habitats | Han Y.-G., Yoo S.H., Kwon O. | 2017 | Abundance, habitat | Phalacrocoracidae spp., Laridae spp | NA | Individuals/groups | Multi-rotor | 4-copter, electric (DJI Phantom 4) | Manual | Yes | Yes | Web of science/Scopus | Laridae excluded from disturbance table as only one individual detected from this family |
| Unmanned aircraft systems to unravel spatial and temporal factors affecting dynamics of colony formation and nesting success in birds | Sardà-Palomera F., Bota G., Padilla N., Brotons L., Sardà  F. | 2017 | Breeding success | Black-headed Gull *Chroicocephalus ridibundus* | Breeding | Colony | Fixed-wing | 4-copter, electric (DJI Phantom 2 Vision+, Inspire 1, and Phantom 4) | Manual | Yes | No | Web of science/Scopus |  |
| Monitoring penguin colonies in the Antarctic using remote sensing data | Mustafa, O., Esefeld, J., Grämer, H., Maercker, J., Rümmler, M.-C., Senf, M., Peter, H.-U. & Pfeifer, C. | 2017 | Detection, abundance, disturbance, phenology | Gentoo Penguin *Pygoscelis papua*, Adélie penguin *Pygoscelis adeliae*, Chinstrap Penguin *Pygoscelis antarctica* | Breeding | Colony | Multi-rotor | Fixed-wing, electric (Skywalker) | Manual | Yes | No | Google scholar |  |
| Report on a visit to Falklands Conservation owned North, Saddle, Cliff Knob, Ship and Coffin Islands | Stanworth, A., Bertram, E. Winnard, M. and Ireland, L. | 2017 | Abundance | Black-browed Alabtross *Thalassarche melanophris*, Southern Rockhopper Penguin *Eudyptes chrysocom*e, King Shag *Phalacrocorax atriceps*, Southern Giant Petrel *Macronectes giganteus*, | Breeding | Colony | NA | 8-copter, electric (HiSystems, MK ARF Okto XL) | Manual | Yes | Yes | Google scholar | Not included in disturbance table: disturbance not measured/recorded |
| A new use of technology to solve an old problem: Estimating the population size of a burrow nesting seabird | Albores-Barajas Y.V., Soldatini C., Ramos-Rodríguez, A., Alcala-Santoyo J.E., Carmona R., Dell'Omo G. | 2018 | Abundance | Western Gull *Larus occidentalis* | Breeding | Colony | Multi-rotor | NA | Manual | No | No | Web of science/Scopus |  |
| Detectability and visibility biases associated with using a consumer-grade unmanned aircraft to survey nesting colonial waterbirds | Barr J.R., Green M.C., DeMaso S.J., Hardy T.B. | 2018 | Abundance, detection | Black Skimmers *Rynchops niger*, Tern spp | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 3 Standard) | Manual | Yes | Yes | Web of science/Scopus | Not included in disturbance table: study used seabird decoys instead of flying over live seabirds |
| Multi-modal survey of Adelie penguin mega-colonies reveals the Danger Islands as a seabird hotspot | Borowicz, A; McDowall, P; Youngflesh, C; Sayre-McCord, T; Clucas, G; Herman, R; Forrest, S; Rider, M; Schwaller, M; Hart, T; Jenouvrier, S; Polito, MJ; Singh, H; Lynch, HJ | 2018 | Abundance | Adélie penguin *Pygoscelis adeliae* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 3 Pro) | Manual | No | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/, although authors said height was chosen to 'avoid disturbance to wildlife' |
| Drones count wildlife more accurately and precisely than humans | Hodgson J.C., Mott R., Baylis S.M., Pham T.T., Wotherspoon S., Kilpatrick A.D., Raja Segaran R., Reid I., Terauds A., Koh L.P. | 2018 | Abundance | Greater Crested Tern *Thalasseus bergii* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 3) | Manual, Automated | No | No | Web of science/Scopus | Not included in disturbance table: study used seabird decoys instead of flying over live seabirds |
| Preliminary Evaluation of Behavioral Response of Nesting Waterbirds to Small Unmanned Aircraft Flight | Reintsma K.M., McGowan P.C., Callahan C., Collier T., Gray D., Sullivan J.D., Prosser D.J. | 2018 | Disturbance | Common Tern *Sterna hirundo* | Breeding | Colony | Multi-rotor | 4-copter, electric (Iris+, 3D Robotics) | Manual, Semi-automated | No | Yes | Web of science/Scopus |  |
| Sensitivity of Adelie and Gentoo penguins to various flight activities of a micro UAV | Rúmmler, MC; Mustafa, O; Maercker, J; Peter, HU; Esefeld, J | 2018 | Disturbance | Adélie Penguin *Pygoscelis adeliae*, Gentoo Penguin *Pygoscelis papua* | Breeding | Colony | Multi-rotor | 6-copter, electric (Storm Drone 6 V3 GPS Flying Platform) and 4-copter, electric (DJI Inspire 1 v2.0) | Manual | Yes | Yes | Web of science/Scopus |  |
| Can drones count gulls? Minimal disturbance and semiautomated image processing with an unmanned aerial vehicle for colony-nesting seabirds | Rush G.P., Clarke L.E., Stone M., Wood M.J. | 2018 | Abundance, disturbance | Lesser Black-backed Gull *Larus fuscus* | Breeding | Colony | Multi-rotor | 8-copter, electric (HiSystems, MK ARF Okto XL) | Manual | Yes | No | Web of science/Scopus |  |
| Data Imaging Acquisition and Processing as a Methodology for Estimating the Population of Frigates Using UAVs | Villegas P., Mena L., Constantine A., Villalba R., Ochoa D. | 2018 | Abundance | Magnificent Frigatebird, *Fregata magnificens* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Inspire 1) | Semi-automated | Yes | No | Web of science/Scopus |  |
| Flights of drones over sub-Antarctic seabirds show species- and status-specific behavioural and physiological responses | Weimerskirch H., Prudor A., Schull Q. | 2018 | Disturbance | King Penguin *Aptenodytes patagonicus*, Macaroni penguin *Eudyptes chrysolophus*, Southern rock-hopper penguin *Eudyptes chrysocome*, Southern giant petrel *Macronectes giganteus*, Northern giant petrel *Macronectes halli*, Wandering albatross *Diomedea exulans*, Sooty albatross *Phoebetria fusca*, Light-mantled sooty albatross *Phoebetria palpebrata*, Imperial Cormorant *Leucocarbo atriceps*, Brown/South Polar Skua *Catharacta antarctica/C. maccormicki* | Breeding and Non-breeding | Colony and small group | Multi-rotor | 8-copter, electric (X8+ 3D Robotics) | Manual | Yes | No | Web of science/Scopus |  |
| Application of UAV BVLOS remote sensing data for multi-faceted analysis of Antarctic ecosystem | Zmarz A., Rodzewicz M., Dąbski, M., Karsznia I., Korczak-Abshire M., Chwedorzewska K.J. | 2018 | Abundance, distribution, body size | Adélie Penguin *Pygoscelis adeliae*, Chinstrap Penguin *Pygoscelis antarcticus* | Breeding | Colony | Fixed-wing | 4-copter, electric (DJI Phantom 3) | Manual | Yes | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| A census of breeding Manx Shearwaters Puffinus puffinus on the Pembrokeshire Islands of Skomer, Skokholm and Midland in 2018 | Perrins, C., Padget, O., O’Connell, M., Brown, R., Büche, B., Eagle, G., Roden, J., Stubbings, E. & Wood, M.J. 2 | 2018 | Habitat | Manx Sheawater *Puffinus puffinus* | Breeding | Colony | Fixed-wing | Fixed-wing, electric (PW-ZOOM) | Manual | No | No | Google scholar | Information on drone obtained from paper reference: https://www.welshwildlife.org/sites/default/files/2022-03/Management-Plan-Vegetation-Skomer-revised-2020.pdf. Not included in disturbance table: disturbance not measured/recorded. |
| The use of an Unmanned Aerial Vehicle to census large breeding colonies of black-billed gull (Larus bulleri) and white-fronted tern (Sterna striata) at the Ashburton River/Hakatere River mouth | Bell M., Harborne P. | 2019 | Abundance | Black-billed Gull *Larus bulleri*, White-fronted Tern *Sterna striata* | Breeding | Colony | Multi-rotor | Fixed-wing, electric (Sensefly Swinglet CAM) | Manual | No | No | Web of science/Scopus |  |
| Estimating waterbird abundance on catfish aquaculture ponds using an unmanned aerial system | Burr P.C., Samiappan S., Hathcock L.A., Moorhead R.J., Dorr B.S. | 2019 | Abundance, detection | Double-crested Cormorants *Phalacrocorax auritus* | NA | Individuals | Fixed-wing | 4-copter, electric (DJI Phantom 3) | Manual | Yes | Yes | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| INTRASEASONAL VARIABILITY of GUANO STAINS in A REMOTELY SENSED PENGUIN COLONY USING UAV and SATELLITE | Firla M., Mustafa O., Pfeifer C., Senf M., Hese S. | 2019 | Distribution | Gentoo Penguin, Pygoscelis *papua* | Breeding | Colony | Multi-rotor | Fixed-wing, electric (PrecisionHawk Lancaster and Robota Triton) | Manual, Automated | No | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded and no flight details provided |
| Response of colonial Peruvian guano birds to flying UAVs: effects and feasibility for implementing new population monitoring methods | Irigoin-Lovera, C; Luna, DM; Acosta, DA; Zavalaga, CB | 2019 | Disturbance | Guanay cormorant *Phalacrocorax bougainvilli*, Peruvian Booby *Sula variegata*, Peruvian Pelican *Pelecanus thagus* | Breeding and Non-breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4 Pro) | Semi-automated | No | No | Web of science/Scopus |  |
| Study of fauna population changes on Penguin Island and Turret Point Oasis (King George Island, Antarctica) using an unmanned aerial vehicle | Korczak-Abshire M., Zmarz A., Rodzewicz M., Kycko M., Karsznia I., Chwedorzewska K.J. | 2019 | Abundance | Adélie Penguin *Pygoscelis adeliae*, Chinstrap Penguin *Pygoscelis antarcticus*, Southern Giant Petrel *Macronectes giganteus*, Antarctic Shag *Phalacrocorax atriceps bransfieldensis* | Breeding | Colony | Fixed-wing | 4-copter, electric (DJI Phantom 3) | Manual | Yes | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Localised anthropogenic wake generates a predictable foraging hotspot for top predators | Lieber L., Nimmo-Smith W.A.M., Waggitt J.J., Kregting L. | 2019 | Foraging | Common Tern *Sterna hirundo*, Arctic Tern *S. paradisaea* & Sandwich Tern *S. sandvicensi* | Foraging | Feeding flock | Multi-rotor | Fixed-wing, electric (PW-ZOOM) | Manual | No | No | Web of science/Scopus |  |
| Evaluation of small unmanned aerial systems as a census tool for aleutian tern onychoprion aleuticus colonies | Magness D.R., Eskelin T., Laker M., Renner H.M. | 2019 | Abundance, breeding success | Aleutian Tern *Onychoprion aleutic* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic Pro) | Automated | Yes | No | Web of science/Scopus |  |
| Aerial VHF tracking of wildlife using an unmanned aerial vehicle (UAV): comparing efficiency of yellow-eyed penguin (Megadyptes antipodes) nest location methods | Muller, CG; Chilvers, BL; Barker, Z; Barnsdale, KP; Battley, PF; French, RK; McCullough, J; Samandari, F | 2019 | Detection | Yellow-eyed Penguin *Megadyptes antipodes* | Breeding | Colony | Multi-rotor | 4-copter, electric (3DR Solo) | Manual | Yes | Yes | Web of science/Scopus |  |
| DETECTING ANTARCTIC SEALS and FLYING SEABIRDS by UAV | Mustafa O., Braun C., Esefeld J., Knetsch S., Maercker J., Pfeifer C., Rúmmler M.-C. | 2019 | Detection | Antarctic Shag *Phalacrocorax atriceps*, Antarctic Tern *Sterna vittata*, Kelp Gull *Larus dominicanus*, Skua Catharacta spec., Snowy Sheathbill *Chionis alba*, Southern Giant Petrel *Macronectes giganteus* | Breeding | Colony | Fixed-wing and Multi-rotor | 4-copter, electric (SteadiDrone) | NA | Yes | Yes | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Using Fixed-Wing UAV for Detecting and Mapping the Distribution and Abundance of Penguins on the South Shetlands Islands, Antarctica | Pfeifer, C; Barbosa, A; Mustafa, O; Peter, HU; Rúmmler, MC; Brenning, A | 2019 | Abundance, distribution | Chinstrap Penguin *Pygoscelis antarctica* | Breeding | Colony | Fixed-wing | 8-copter (Mikrokopter MK), 4-copter (DJI Phantom 4 Pro), fixed-wing (Bormatec Ninox) | Manual | No | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded. Compared drone surveys with previous surveys conducted by boat. |
| Evaluating drone-based techniques to census an urban-nesting gull population on Canada’s Pacific coast | Blight, L.K., Bertram, D.F. & Kroc, E. | 2019 | Abundance, disturbance | Glaucous-winged Gull *Larus glaucescens* | Breeding | Colony (urban) | Fixed-wing and Multi-rotor | Fixed-wing, electric (Bormatec Ninox) | Manual | No | Yes | Google scholar |  |
| Sule Skerry – an overspill gannetry from Sule Stack | Harris, M.P., Blackburn, J., Budworth, D. & Blackburn, A.C. | 2019 | Abundance | Northern Gannets *Morus bassanus* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4 Pro and DJI Inspire 1) and fixed-winge, electric (senseFly eBee Plus) | Manual | Yes | No | Google scholar | Not included in disturbance table: disturbance not measured/recorded |
| Drone Surveys Do Not Increase Colony-wide Flight Behaviour at Waterbird Nesting Sites, But Sensitivity Varies Among Species | Barr J.R., Green M.C., DeMaso S.J., Hardy T.B. | 2020 | Disturbance | Laughing Gull *Leucophaeus atricilla*, Royal Tern *Thalasseus maximus*, Black Skimmer *Rynchops niger* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4) | Manual | No | No | Web of science/Scopus |  |
| A Semi-Automated Method for Estimating Adelie Penguin Colony Abundance from a Fusion of Multispectral and Thermal Imagery Collected with Unoccupied Aircraft Systems | Bird, C.N, Dawn, A.H., Dale, J., Johnston, D.W. | 2020 | Abundance | Adélie penguin *Pygoscelis adeliae* | Breeding | Colony | Fixed-wing | 4-copter, electric (DJI Phantom 3) | Manual | Yes | No | Web of science/Scopus |  |
| Counting Mixed Breeding Aggregations of Animal Species Using Drones: Lessons from Waterbirds on Semi-Automation | Francis, RJ; Lyons, MB; Kingsford, RT; Brandis, KJ | 2020 | Abundance | Pink-backed Pelican *Pelecanus onocrotalus* | Breeding | Colony | Multi-rotor | Fixed-wing, electric (senseFly eBee) | Manual, Semi-automated | Yes | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Towards Efficient Machine Learning Methods for Penguin Counting in Unmanned Aerial System Imagery | Liu Y., Shah V., Borowicz A., Wethington M., Strycker N., Forrest S., Lynch H., Singh H. | 2020 | Abundance | Chinstrap Penguin *Pygoscelis antarctica* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4 Advanced) | Semi-automated | No | No | Web of science/Scopus |  |
| Long-term Declines in the Size of Northern Fulmar (Fulmarus glacialis) Colonies on Eastern Baffin Island, Canada | Mallory, ML; Dey, CJ; McIntyre, J; Pratte, I; Mallory, CL; Francis, CM; Black, AL; Geoffroy, C; Dickson, R; Provencher, JF | 2020 | Abundance | Northern Fulmar *Fulmarus glacialis* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4) | Automated | Yes | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Thermal Imaging of Beach-Nesting Bird Habitat with Unmanned Aerial Vehicles: Considerations for Reducing Disturbance and Enhanced Image Accuracy | Mapes, KL; Pricope, NG; Baxley, JB; Schaale, LE; Danner, RM | 2020 | Habitat, disturbance | Least Tern *Sternula antillarum* | Breeding | Colony | Fixed-wing | 4-copter, electric (DJI Phantom 4 Pro) | Manual | No | No | Web of science/Scopus |  |
| Unmanned aerial vehicle (UAV) survey of the Antarctic shag (Leucocarbo bransfieldensis) breeding colony at Harmony Point, Nelson Island, South Shetland Islands | Oosthuizen W.C., Krüger L., Jouanneau W., Lowther A.D. | 2020 | Abundance | Antarctic Shag *Leucocarbo bransfieldensis* | Breeding | Colony | Multi-rotor | Fixed-wing, electric (senseFly eBee Plus) | Manual | Yes | No | Web of science/Scopus |  |
| Multidrone aerial surveys of penguin colonies in Antarctica | Shah K., Ballard G., Schmidt A., Schwager M. | 2020 | Protocol | Adélie Penguin, *Pygoscelis adeliae* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4 Advanced) | Manual | Yes | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| A global population assessment of the Chinstrap penguin (Pygoscelis antarctica) | Strycker N., Wethington M., Borowicz A., Forrest S., Witharana C., Hart T., Lynch H.J. | 2020 | Abundance | Chinstrap Penguin *Pygoscelis antarctica* | Breeding | Colony | NA | NA | Automated | No | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Escape responses of terrestrial and aquatic birds to drones: Towards a code of practice to minimize disturbance | Weston M.A., O'Brien C., Kostoglou K.N., Symonds M.R.E. | 2020 | Disturbance | Silver Gull *Chroicocephalus novaehollandiae*, Little Black Cormorant *Phalacrocorax sulcirostris*, Pacific Gull *Larus pacificus*, Australian Pelican *Pelecanus conspicillatus*, Pied Cormorant *Phalacrocorax varius* | NA | NA | Multi-rotor | NA | Manual | No | No | Web of science/Scopus | (Little Black Cormorant, Pelican and Pacific gull not included in disturbance table because flights for < 10 individuals were recorded for these species |
| Spatial distribution analysis of Black-legged Kittiwakes and Northern Fulmars in Svalbard coastal cliffs using remotely piloted aircraft system | Park, M | 2020 | Distribution | Black-legged Kittiwake *Rissa tridactyla*, Northern Fulmar *Fulmarus glacialis* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 3) | Manual | Yes | Yes | Google scholar |  |
| Campbell Island seabirds: Operation Endurance November 2019 | Rexer-Huber K., Parker K.A., Parker G.C. | 2020 | Abundance | Campbell Albatross *Thalassarche impavida*, Grey-headed Albatross *Thalassarche chrysostoma* | Breeding | Colony | Multi-rotor | 4-copter, electric (DAYA-550 Alien Carbon, Fiber Folding Quadcopter Frame Kit with 4 motors and 12-inch propellors) | Manual, Semi-automated | Yes | No | Google scholar |  |
| Bounty Islands drone trials: feasibility for population assessment of NZ fur seal | Rexer-Huber, K. & Parker, G. | 2020 | Disturbance | Salvin's Albatross *Thalassarche salvini*, Erect-crested Penguin *Eudyptes sclateri*, Fulmar Prion *Pachyptila crassirostris*, Kelp Gull *Larus dominicanus* | Breeding and Non-breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic 2 Pro) | Manual | Yes | No | Google scholar |  |
| Drone-based Salvin’s albatross population assessment: feasibility at the Bounty Islands | Parker, G.C. & Rexer-Huber, K. | 2020 | Abundance | Salvin's Albatross *Thalassarche salvini* | Breeding and Non-breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic 2 Pro) | Manual | Yes | No | Google scholar | Not included in disturbance table: disturbance not measured/recorded |
| Testing the potential of lightweight drones as a tool for monitoring the status of colonially breeding Saunders's gulls (Saundersilarus saundersi) | Choi, H-I., Nam, H-K. & Yoon J. | 2020 | Abundance, breeding success | Saunder’s Gull *Saundersilarus saundersi* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic 2 Pro) | Manual | No | Yes | Google scholar |  |
| Falkland Islands Seabird Monitoring Programme Annual Report 2019/2020 (SMP27) | Crofts, S. & Stanworth, A. | 2020 | Abundance, breeding success | Gentoo Penguin *Pygoscelis papua*, Southern Rockhopper *Eudyptes c. chrysocome*, Black-browed Albatross *Thalassarche melanophris*, Southern Giant Petrel *Macronectes giganteus* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic Pro) | Manual | Yes | Yes | Google scholar |  |
| Population trends of Imperial Cormorants (Leucocarbo atriceps) in northern coastal Argentine Patagonia over 26 years | Yorio, P., Pozzi, L., Herrera, G., Punta, G., Svagelj, W. S. & Quintana, F. | 2020 | Abundance | Imperial Cormorant *Leucocarbo atriceps* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4) | Manual | Yes | No | Google scholar |  |
| Acute and chronic behavioral effects of kelp gull micropredation on southern right whale mother-calf pairs off Peninsula Valdes, Argentina | Azizeh, T.R., Sprogis, K.R., Soley, R., Nielsen, M.L.K., Uhart, M.M., Sironi, M., Maron, C.F., Bejder, L., Madsen, P.T., Christiansen, F. | 2021 | Foraging | Kelp Gull *Larus dominicanus* | Non-breeding | Individuals | Multi-rotor | 4-copter, electric (DJI Phantom 3) | Manual | Yes | No | Web of science/Scopus |  |
| Retreating Shorelines as an Emerging Threat to Adelie Penguins on Inexpressible Island | Chen, XT; Chen, JQ; Cheng, X; Zhu, LZ; Li, B; Li, XL | 2021 | Abundance | Adélie penguin *Pygoscelis adeliae* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic Pro Platinum; DJI Phantom 3 Professional) | Manual | Yes | NA | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Counting breeding gulls with unmanned aerial vehicles: camera quality and flying height affects precision of a semi-automatic counting method | Corregidor-Castro, A; Hohn, TE; Bregnballe, T | 2021 | Abundance | Herring Gull *Larus argentatus*, Lesser Black-backed Gull *Larus fuscus* | Breeding | Colony | Fixed-wing and Multi-rotor | 6-copter, electric (DJI Matrice 600 Pro) | Semi-automated | No | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Developing UAV Monitoring of South Georgia and the South Sandwich Islands' Iconic Land-Based Marine Predators | Dickens, J; Hollyman, PR; Hart, T; Clucas, GV; Murphy, EJ; Poncet, S; Trathan, PN; Collins, MA | 2021 | Abundance | Wandering Albatross *Diomedea exulans*, Adélie Penguin *Pygoscelis adeliae*, Chinstrap Penguin *Pygoscelis antarctica*, King Penguin *Aptenodytes patagonicus*, Macaroni penguin *Eudyptes chrysolophus* | Breeding | Colony | Multi-rotor | Fixed-wing, electric (E384) and 4-copter, electric (DJI Phantom 4 Pro; DJI Matrice 210) | Manual, Semi-automated | No | Yes | Web of science/Scopus |  |
| Un-crewed aerial vehicle population survey of three sympatrically breeding seabird species at Signy Island, South Orkney Islands | Dunn M.J., Adlard S., Taylor A.P., Wood A.G., Trathan P.N., Ratcliffe N. | 2021 | Abundance | Gentoo Penguin *Pygoscelis papua*, Chinstrap Penguin *Pygoscelis antarctica*, South Georgia Shag *Leucocarbo atriceps georgianus* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic 2 Pro) | Manual | Yes | No | Web of science/Scopus |  |
| Drones, Gulls and Urbanity: Interaction between New Technologies and Human Subsidized Species in Coastal Areas | Frixione, MG; Salvadeo, C | 2021 | Disturbance | Yellow-footed Gull *Larus livens* | Non-breeding | Individuals | Multi-rotor | 4-copter, electric (DJI Phantom 4 Pro) | Manual | Yes | Yes | Web of science/Scopus |  |
| Using drones and ROV to assess the vulnerability of marine megafauna to the Fundao tailings dam collapse | Giacomo, ABD; Barreto, J; Teixeira, JB; Oliveira, L; Cajaiba, L; Joyeux, JC; Barcelos, N; Martins, AS | 2021 | Detection | Large-billed Tern *Phaetusa simplex*, Common Tern *Sterna hirundo*, Tern spp., Albatross Thalassarche sp., Magnificent Frigatebird *Fregata magnificens*, Masked Booby *Sula dactylatra*, Brown Booby *Sula leucogaster*, Unknown seabird spp. | NA | Individuals/groups | Multi-rotor | 4-copter, electric (DJI Spark) | Manual | Yes | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Silver gull harassment of humpback whales in Exmouth Gulf, Western Australia | Harkness P., Sprogis K.R. | 2021 | Foraging | Silver Gull *Chroicocephalus novaehollandiae* | Non-breeding | Individuals | NA | 4-copter, electric (DJI Mavic 2 Zoom) | Manual | No | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Drones and deep learning produce accurate and efficient monitoring of large-scale seabird colonies | Hayes M.C., Gray P.C., Harris G., Sedgwick W.C., Crawford V.D., Chazal N., Crofts S., Johnston D.W. | 2021 | Abundance | Black-browed Albatrosses *Thalassarche melanophris*, Southern Rockhopper Penguin *Eudyptes c. chrysocome* | Breeding | Colony | Multi-rotor | NA | Manual | No | NA | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Polar bears are inefficient predators of seabird eggs | Jagielski P.M., Dey C.J., Gilchrist H.G., Richardson E.S., Love O.P., Semeniuk C.A.D. | 2021 | Predation | Common Eider *Somateria mollissima* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom) | Manual, Automated | No | No | Web of science/Scopus | Not included in disturbance table: purpose was to record Polar Bears flushing eiders |
| Validating an Unmanned Aerial Vehicle (UAV) Approach to Survey Colonial Waterbirds | Jones L.R., Godollei E., Sosa A., Hucks K., Walter S.T., Leberg P.L., Spring J. | 2021 | Abundance | Brown Pelican *Pelecanus occidentalis* | Breeding | Colony | Fixed-wing | 4-copter, electrc (DJI Phantom 3 Pro and 4 Pro) | Manual | No | No | Web of science/Scopus |  |
| 21 000 birds in 4.5 h: efficient large-scale seabird detection with machine learning | Kellenberger, B; Veen, T; Folmer, E; Tuia, D | 2021 | Abundance | African Royal Tern *Thalasseus maximus*, Caspian Tern *Hydroprogne caspia*, Slender-billed Gull *Chroicocephalus genei*, Grey-headed gulls *Chroicocephalus cirrocephalus* | Breeding | Colony | Multi-rotor | Fixed-wing, electric (type not given) | Manual | Yes | Yes | Web of science/Scopus |  |
| Drones Minimize Antarctic Predator Responses Relative to Ground Survey Methods: An Appeal for Context in Policy Advice | Krause D.J., Hinke J.T., Goebel M.E., Perryman W.L. | 2021 | Disturbance | Chinstrap Penguin *Pygoscelis antarctica* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4 Pro) | Automated | Yes | No | Web of science/Scopus |  |
| A bird's-eye view on turbulence: seabird foraging associations with evolving surface flow features | Lieber, L; Langrock, R; Nimmo-Smith, WAM | 2021 | Foraging | Common Tern *Sterna hirundo*, Arctic Tern *S. paradisaea* & Sandwich Tern *S. sandvicensi* | Foraging | Feeding flock | Multi-rotor | 6-copter, electric (Aerial Imaging Solutions, APH-22) | Manual | Yes | Yes | Web of science/Scopus |  |
| Erect-crested penguins on the Bounty Islands: population size and trends determined from ground counts and drone surveys | Mattern T., Rexer-Huber K., Parker G., Amey J., Green C.-P., Tennyson A.J.D., Sagar P.M., Thompson D.R. | 2021 | Abundance | Erect-crested Penguin *Eudyptes sclateri* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 3) | Automated | Yes | No | Web of science/Scopus |  |
| Dual visible-thermal camera approach facilitates drone surveys of colonial marshbirds | McKellar A.E., Shephard N.G., Chabot D. | 2021 | Abundance | Franklin's Gull *Leucophaeus pipixcan*, Forster's Tern *Sterna forsteri*, Black Tern *Chlidonias niger* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic 2 Pro) | Manual | Yes | Yes | Web of science/Scopus |  |
| Assessing colonies of Antarctic shags by unmanned aerial vehicle (UAV) at South Shetland Islands, Antarctica | Pfeifer C., Rúmmler M.-C., Mustafa O. | 2021 | Abundance, distribution | Antarctic Shag *Leucocarbo bransfieldensis* | Breeding | Colony | Fixed-wing | 8-copter, electric (DJI S1000+ airframe) | Manual | Yes | Yes | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Emperor penguin reactions to UAVs: First observations and comparisons with effects of human approach | Rúmmler M.-C., Esefeld J., Hallabrin M.T., Pfeifer C., Mustafa O. | 2021 | Disturbance | Emperor Penguin *Aptenodytes forsteri* | Breeding | Colony | Multi-rotor | Fixed-wing, electric (Bormatec Ninox) | Manual | No | No | Web of science/Scopus |  |
| Effects of UAV overflight height, UAV type, and season on the behaviour of emperor penguin adults and chicks | Rúmmler M.-C., Esefeld J., Pfeifer C., Mustafa O. | 2021 | Disturbance | Emperor Penguin *Aptenodytes forsteri* | Breeding | Colony | Fixed-wing and Multi-rotor | 4-copter, electric (DJI Phantom 4 Pro) | Manual | Yes | Yes | Web of science/Scopus |  |
| Fifty-year change in penguin abundance on Elephant Island, South Shetland Islands, Antarctica: results of the 2019-20 census | Strycker, N; Borowicz, A; Wethington, M; Forrest, S; Shah, V; Liu, Y; Singh, H; Lynch, HJ | 2021 | Abundance | King Penguin *Aptenodytes patagonicus*, Macaroni penguin *Eudyptes chrysolophus*, Chinstrap Penguin *Pygoscelis antarctica*, Gentoo Penguin *Pygoscelis papua*, Adélie Penguin, *Pygoscelis adeliae* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4 Pro) & fixed-wing, electric (Magpy, MAPIR | Manual | Yes | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Multiscale mapping of plant functional groups and plant traits in the High Arctic using field spectroscopy, UAV imagery and Sentinel-2A data | Thomson E.R., Spiegel M.P., Althuizen I.H.J., Bass P., Chen S., Chmurzynski A., Halbritter A.H., Henn J.J., Jónsdóttir I.S., Klanderud K., Li Y., Maitner B.S., Michaletz S.T., Niittynen P., Roos R.E., Telford R.J., Enquist B.J., Vandvik V., Macias-Fauria M., Malhi Y. | 2021 | Effect on vegetation | Little Auk *Alle alle*, Black-legged Kittiwake *Rissa tridactyla* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4) | Manual | No | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Drone-conducted counts as a tool for the rapid assessment of productivity of Sandwich Terns (Thalasseus sandvicensis) | Valle R.G., Scarton F. | 2021 | Breeding success | Sandwich Tern *Sterna sandvicensi* | Breeding | Colony | Multi-rotor | 4-copter, electric (3DR Solo) | Automated | No | No | Web of science/Scopus |  |
| Monitoring the Hatching Success of Gulls Laridae and Terns Sternidae: A Comparison of Ground and Drone Methods | Valle R.G., Scarton F. | 2021 | Breeding success | Slender-billed Gull *Chroicocephalus genei*, Mediterranean Gull *Larus melanocephalus* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic Pro) | Manual | Yes | Yes | Web of science/Scopus |  |
| Foveaux and Otago shag population census methods: drone and camera trials | Parker, G.C. & Rexer-Huber, K. | 2021 | Abundance, disturbance | Foveaux Shag *Leucocarbo stewartia*, Otago Shag *Leucocarbo chalconotus*, Spotted Shag *Phalacrocorax punctatusm*, Red-billed Gull *Chroicocephalus novaehollandiae scopulinus* | Non-breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic Pro) | Manual | Yes | Yes | Google scholar |  |
| Drone assessment of habitat selection and breeding success of Gull-billed Tern Gelochelidon nilotica nesting on low-accessibility sites: a case study | Scarton, F. & Valle, R. | 2021 | Habitat, breeding success | Gull-billed Tern *Gelochelidon nilotica* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic 2 Pro) | Manual | Yes | No | Google scholar |  |
| Drone-Monitoring: Improving the Detectability of Threatened Marine Megafauna | Barreto, J., Cajaíba, L., Teixeira, J. B., Nascimento, L., Giacomo, A., Barcelos, N., Fettermann, T. & Martins, A. | 2021 | Detection | Magnificent Frigatebird *Fregata magnificens*, Masked Booby *Sula dactylatra*, Brown Booby *Sula leucogaster*, Albatross Thalassarche sp., Common Tern *Sterna hirundo*, Large-billed Tern *Phaetusa simplex* | NA | Individuals/groups | Multi-rotor | 4-copter, electric (DJI Mavic Pro) | Manual | Yes | No | Google scholar |  |
| Is Sula sula breeding in the cliffs of Baía do Inferno, Santiago Island, Cabo Verde? | Loureiro, N.S., Reis, E., Dias, D. & Veiga, A. | 2021 | Detection, distribution | Red-footed Booby *Sula sula* | Breeding and Non-breeding (immatures) | Individuals | Multi-rotor | 4-copter, electric (DJI Mavic 2 Zoom) | Manual | Yes | No | Google scholar | Not included in disturbance table: disturbance not measured/recorded |
| Applications of unmanned aerial vehicles in Antarctic environmental research | Tovar-Sánchez, A., Román, A., Roque-Atienza, D. & Navarro, G. | 2021 | Distribution | Chinstrap Penguin *Pygoscelis antarctica* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4 Pro) | Manual | No | No | Google scholar | Not included in disturbance table: disturbance not measured/recorded |
| Nesting Common Eiders (Somateria mollissima) show little behavioral response to fixed-wing drone surveys | Ellis-Felege, S. N., Stechmann, T., Hervey, S., Felege, C. J., Rockwell, R. F. & Barnas, A. F. | 2021 | Disturbance | Common Eider *Somateria mollissima* | Breeding | Colony | Fixed-wing | 4-copter, electric (DJI Mavic 2 Zoom; DJI P4 Multispectral), 6-copter, electric (Condor, Dronetools) | Automated | No | No | Google scholar |  |
| Predatory cue use in flush responses of a colonial nesting seabird during polar bear foraging | Barnas A.F., Geldart E.A., Love O.P., Jagielski P.M., Harris C.M., Gilchrist H.G., Hennin H.L., Richardson E.S., Dey C.J., Semeniuk C.A.D. | 2022 | Predation | Common Eider *Somateria mollissima* | Breeding | Colony | Multi-rotor | Fixed-wing, electric (Trimble UX5) | Manual | Yes | No | Web of science/Scopus | Not included in disturbance table: purpose was to record Polar Bears flushing eiders |
| NESTING DISTRIBUTION OF MASKED BOOBY SULA DACTYLATRA AT TRINDADE ISLAND, WESTERN SOUTH ATLANTIC OCEAN | Benemann V.R., Araújo L.D., Fabbris A.Z., Montone R.C., Petry M.V. | 2022 | Distribution | Masked Booby *Sula dactylatra* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom3; DJI Phantom 4) | Manual | No | NA | Web of science/Scopus | Not included in disturbance table: details of drone survey not provided |
| Surveying cliff-nesting seabirds with unoccupied aircraft systems in the Gulf of Alaska | Bishop A.M., Brown C.L., Christie K.S., Kettle A.B., Larsen G.D., Renner H.M., Younkins L. | 2022 | Abundance, disturbance | Black-legged Kittiwake *Rissa tridactyla*, Common Murre *Uria aalge*, Pelagic *Phalacrocorax pelagicus*, Double-crested Cormorant *Phalacrocorax auratus* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic Pro) | Manual | No | No | Web of science/Scopus | Compared with vessel based photography |
| Monitoring Colonies of Large Gulls Using UAVs: From Individuals to Breeding Pairs | Corregidor-Castro A., Riddervold M., Holm T.E., Bregnballe T. | 2022 | Abundance | Herring Gull *Larus argentatus*, Lesser Black-backed Gull *Larus fuscus* | Breeding | Colony | Fixed-wing and Multi-rotor | 4-copter, electric (DJI Inspire 2 and DJI Mavic Air) | Manual | Yes | Yes | Web of science/Scopus |  |
| Semi-automated counts on drone imagery of breeding seabirds using free accessible software | Corregidor-Castro, A; Valle, RG | 2022 | Abundance | Mediterranean Gull *Ichthyateus melanocephalus* | Breeding | Colony | Multi-rotor | Fixed-wing, electric (E384) and 4-copter, electric (DJI Phantom 4 Pro) | Manual | Yes | Yes | Web of science/Scopus |  |
| To fly or not to fly? Comparing vantage point and uncrewed aerial vehicle surveys for assessments of seabird abundance and fine-scale distribution | Costagliola-Ray M.M., Lieber L., Nimmo-Smith W.A.M., Masden E.A., Caplat P., Wilson J., O'Hanlon N.J. | 2022 | Abundance, distribution | Terns Sternidae | Foraging | Feeding flock/individuals | Multi-rotor | 4-copter, electric (DJI Mavic Pro) | Manual, Semi-automated | Yes | No | Web of science/Scopus |  |
| Using drones and citizen science counts to track colonial waterbird breeding, an indicator for ecosystem health on the Chobe River, Botswana | Francis R.J., Kingsford R.T., Brandis K.J. | 2022 | Abundance, breeding success | Reed Cormorant *Microcarbo africanus*, White-breasted Cormorant *Phalocrocorax lucidus* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic Pro and DJI Phantom 3 Advanced) | Manual | Yes | Yes | Web of science/Scopus |  |
| The use of drone-based aerial photogrammetry in population monitoring of Southern Giant Petrels in ASMA 1, King George Island, maritime Antarctica | Fudala, K; Bialik, RJ | 2022 | Abundance, breeding success, disturbance | Southern Giant Petrel | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4 Advanced) | Manual | Yes | No | Web of science/Scopus |  |
| A colonial-nesting seabird shows no heart-rate response to drone-based population surveys | Geldart E.A., Barnas A.F., Semeniuk C.A.D., Gilchrist H.G., Harris C.M., Love O.P. | 2022 | Disturbance | *Macronectes giganteus* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Inspire 2) | Manual | Yes | No | Web of science/Scopus |  |
| Evaluating Thermal and Color Sensors for Automating Detection of Penguins and Pinnipeds in Images Collected with an Unoccupied Aerial System | Hinke J.T., Giuseffi L.M., Hermanson V.R., Woodman S.M., Krause D.J. | 2022 | Abundance, detection | Gentoo Penguin *Pygoscelis papua*, Chinstrap Penguin *Pygoscelis antarctica* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4 Pro) | Manual | Yes | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Selective foraging behavior of seabirds in small-scale slicks | Lieber L., Füchtencordsjürgen C., Hilder R.L., Revering P.J., Siekmann I., Langrock R., Nimmo-Smith W.A.M. | 2022 | Foraging | Common Tern *Sterna hirundo*, Arctic Tern *S. paradisaea* & Sandwich Tern *S. sandvicensi* | Foraging | Feeding flock | Multi-rotor | 6-copter, electric (APH-28) | Automated | No | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Patterns of inter- and intraspecific nest dispersion in colonies of gulls and grebes based on drone imagery | McKellar, AE | 2022 | Distribution | Franklin's Gull *Leucophaeus pipixcan*, Forster's Tern *Sterna forsteri*, Black Tern *Chlidonias niger* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mini 2) | Automated | No | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Prospects for the monitoring of the great cormorant (Phalacrocorax carbo sinensis) using a drone and stationary cameras | Polensky J., Regenda J., Adamek Z., Cisar P. | 2022 | Abundance | Great Cormorant *Phalacrocorax carbo sinensis* | Foraging | Individuals/groups | Multi-rotor | 8-copter, electric (DJI S1000+ airframe) | Manual | No | Yes | Web of science/Scopus |  |
| Use of Unnamed Aerial Vehicles (UAVs) to monitor marine megafauna strandings in beach monitoring programs | Pontalti M., Barreto A.S. | 2022 | Marine strandings | Seabirds recorded: Magellanic Penguin *Spheniscus magellanicus*, Kelp Gull *Larus dominicanus* | NA | NA | Multi-rotor | 4-copter, electric (DJI Phantom 4 and DJI M300) | Automated | Yes | No | Web of science/Scopus | Not included in disturbance table: study was recoridng dead birds from strandings |
| From Coastal to Montane Forest Ecosystems, Using Drones for Multi-Species Research in the Tropics | Rahman, DA; Sitorus, ABY; Condro, AA | 2022 | Abundance, detection, nest contents | Little Black Cormorant *Phalacrocorax sulcirostris* | Breeding | Colony | Multi-rotor | 4-copter, electrci (DJI Phantom 3 Pro) | Manual | NA | Yes | Web of science/Scopus | Not included in disturbance table: disturbance study conducted but difficult to interpret results e.g. responses of birds at different flight heights |
| High-spatial resolution UAV multispectral data complementing satellite imagery to characterize a chinstrap penguin colony ecosystem on deception island (Antarctica) | Román A., Navarro G., Caballero I., Tovar-Sánchez A. | 2022 | Distribution | Chinstrap Penguin *Pygoscelis antarctica* | Breeding | Colony | Multi-rotor | 4-copter (DJI Matrice 300 RTK) | Manual | No - | Yes | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Comparison of drone vs. ground survey monitoring of hatching success in the black-headed gull (Chroicocephalus ridibundus) | Scarton F., Valle R.G. | 2022 | Breeding success | Black-headed Gull *Chroicocephalus ridibundus* | Breeding | Colony | Multi-rotor | 6-copter, electric (Condor) | Automated | No | No | Web of science/Scopus |  |
| Using Unmanned Aerial Vehicle (UAV) Imagery to Characterise Pursuit-Diving Seabird Association With Tidal Stream Hydrodynamic Habitat Features | Slingsby J., Scott B.E., Kregting L., McIlvenny J., Wilson J., Yanez M., Langlois S., Williamson B.J. | 2022 | Foraging | Common Guillemot *Uria aalge*, Razorbill *Alca torda*, Puffins *Fratercula arctica* | Foraging | Individuals/groups | Multi-rotor | 4-copter, electric (DJI Mavic Pro) | Manual | Yes | Yes | Web of science/Scopus |  |
| A new index to assess the state of dune vegetation derived from true colour images | Talavera, L; Costas, S; Ferreira, O | 2022 | Effect on vegetation | Yellow-legged Gull *Larus michahellis*, Audouin’s Gull *Larus audouinii* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4 Advanced) | Manual | Yes | No | Web of science/Scopus | Not included in disturbance table: disturbance not measured/recorded |
| Gibson’s albatross and white-capped albatross in the Auckland Islands 2021–22 | Parker G.C., Elliott G., Walker K., Rexer-Huber K. | 2022 | Abundance, disturbance | White-capped albatross *Thalassarche cauta steadi* | Breeding and Non-breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic 2 Pro) | Automated | No | No | Google scholar |  |
| NA | T. Hart & A. Edney pers. comm. | 2022 | Abundance | European Shag *Gulosus aristotelis* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic 2 Pro) | Manual | Yes | Yes | Personal communication |  |
| NA | I. Juárez- Martinez pers. comm. | 2022 | Abundance | Northern Gannet *Morus bassanus* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic 2 Enterprise Advanced) | NA | Yes | No | Personal communication |  |
| NA | T. Hart & A. Edney pers. comm. | 2022 | Abundance | Black-legged Kittiwake *Rissa tridactyla* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic 2 Pro) | NA | Yes | No | Personal communication |  |
| Estimating population size of red-footed boobies using distance sampling and drone photography | Espíndola W.D., Cruz-Mendoza A., Garrastazú., Nieves M.A., F. Rivera-Milán F., Carlo T.A. | 2023 | Abundance | Red-footed Booby *Sula sula* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Mavic 2 Enterprise Advanced) | NA | Yes | No | Web of science/Scopus |  |
| Adélie penguins north and east of the ‘Adélie gap’ continue to thrive in the face of dramatic declines elsewhere in the Antarctic Peninsula region | Wethington, M., Flynn, C., Borowicz, A. & Lynch, H. J. | 2023 | Abundance | Adélie Penguin *Pygoscelis adeliae*, Gentoo Penguin *Pygoscelis papua* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 3 Advanced) | Manual | Yes | Yes | Google scholar |  |
| Antarctic Ecosystem Recovery Following Human-Induced Habitat Change: Recolonization of Adélie Penguins (Pygoscelis adeliae) at Cape Hallett, Ross Sea | Kim, J-U., Kim, Y., Oh, Y., Kim, H-C. & Kim, J-H. | 2023 | Abundance, distribution | Adélie Penguin *Pygoscelis adeliae* | Breeding | Colony | Multi-rotor | 4-copter, electric (DJI Phantom 4 Pro) | Manual | Yes | Yes | Google scholar | Compared to previous year's data to see how population change, rather than comparing ground and drone data to assess accuracy |

**FRAMEWORK**

**Technology and Training**

**Table A2.** Regulations and permit requirements for flying drones in different countries in April 2022. At least one country is given for each continent. It is the responsibility of the pilot to ensure they are aware of the latest regulations in the country of operation at the time of flight, as requirements regularly change. In 2021, the European Union Aviation Safety Agency (EASA) divided drones into five ‘classes’ from class C0 to class C4 based on different technical requirements, such as weight and noise level. The higher the number of the class, the greater the risk when flying. Since the classes have only recently been introduced drones without a class mark, including privately built aircraft, should be classed by their flying weight. VLOS = Visual Line of Sight, AGL = Above Ground Level.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **Regulating authority** | **Source** | **Drone registration** | **Operation Categories** | | | |
| **Name & description** | **Drone requirements** | **Flight requirements** | **Pilot training** |
| UK | UK Civil Aviation Authority (CAA) | The Air Navigation Order Articles 94 & 95 and CAP 722.  The Drone and Model Aircraft Code, <https://register-drones.caa.co.uk/drone-code> | Operator ID, except if drone is < 250 g/ in the C0 class and does not have a camera. | *Open A1:* basic low-risk flying ‘over’ people | *Weight:* < 250 g  or *Class:* C0 or C1 | *Height:* ≤ 120 m (400 ft) AGL  *People:* no minimum distance from people and can fly over them if drone is < 250 g or C0. If 250-500 g or in the C1 class, should not intentionally fly over people.  *Built-up areas:* can fly here.  *Airspace:* 1000 m away from airport/airfield boundary (i.e. outside of the Flight Restriction Zone). | *1) Flyer ID*  if drone is in the C1 class |
| *Open A2:* basic low-risk, flying ‘close to’ people | *Weight:* < 2 kg  or *Class:* C2 | *Height:* ≤ 120 m (400 ft) AGL  *People:* 50 m distance horizontally and vertically  *Built-up areas:* 150 m away  *Airspace:* 1000 m away from airport/airfield boundary | *1) Flyer ID*  if drone < 250 g or in C0, C1, C2, C3 class  *2) A2 Certificate of Competency* (A2 CofC) |
| *Open A3:* basic low-risk, flying ‘far’ from people | *Weight:* > 2 kg, but < 25 kg  or *Class:* C2, C3 or C4 | *Height:* ≤ 120 m (400 ft) AGL  *People:* 50 m distance horizontally, not allowed to fly overhead  *Built-up areas:* 150 m away  *Airspace:* 1000 m away from airport/airfield boundary | *1) Flyer ID*  if drone > 250 g or in the C1, C2, C3 or C4 classes |
| *Specific:* moderate risk flying that is beyond the limitations of the Open category e.g., flying a drone over an urban area |  |  | *1) Flyer ID*  if drone > 250 g or in the C1, C2, C3 or C4 classes  *2) General VLOS Certificate (GVC)* |
| *Certified:* high-risk, complex flying that needs to be treated in the same way as manned aircraft (aircraft certification, operator certification, pilot licensing) |  |  | UK regulations relating to the Certified category are still being developed and are not yet published, but the same requirements that relate to manned aircraft are applicable |
| US, North America | US Federal Aviation Authority (FAA) | Part 107, <https://www.faa.gov/uas/> | If ≥ 250 g, register via FAADroneZone Portal | *Commercial flying* | *Weight:* < 25 kg | *Height:* ≤ 120 m (400 ft) AGL  *Airspace:* within Class G airspace  *Speed:* ≤ 100 mph  *People:* can fly overhead as long as the requirements defined in the ‘Operations Over People’ rule are met  *Time:* can fly at night as long as the requirements defined in the ‘Operations Over People’ rule are met  *Sight:* Within VLOS  *Vehicles:* Do not operate from a moving vehicle | Remote Pilot Certificate |
| *Part 107 waiver:* excluding the weight and requirement to fly in a Class G airspace, the Part 107 rules can be waived if a Part 107 waiver is submitted and received. |  |  |  |
| *Special airspace authorisation:* allows the Class G airspace requirement to be removed. |  |  |  |
| Brazil, South America | National Civil Aviation Industry - Brazil (ANAC) | <https://www.anac.gov.br/en/drones> | If ≥ 250 g, need to register | *Commercial and recreational* | *Weight:* < 25 kg | *Height:* ≤ 120 m (400 ft) AGL  *People:* 30 m distance horizontally from people who have not consented/are not directly involved in the operation  *Sight:* VLOS | Aircraft inscribed at the System for Unmanned Aircraft (SISANT) |
| *Commercial* | *Weight:* > 25 kg but < 150 kg (RPA Class 2) | Special RPA Certificate of Air Worthiness (CAER) |
| *Weight:* > 150 kg (RPA Class 1) | Standard or Restricted Certificate of Air Worthiness (CofA) |
| *Weight:* < 25 kg  (RPA Class 3) | *Height:* > 120 m (400 ft) AGL  *People:* 30 m distance horizontally from people who have not consented/are not directly involved in the operation  *Sight:* beyond VLOS | Special RPA Certificate of Air Worthiness (CAER) |
| Australia, Australasia | Australian Government Civil Aviation Safety Authority (CASA) | <https://www.casa.gov.au/knowyourdrone> | All drones flown commercially must be registered regardless of weight via myCASA portal. From May 2022 all drones > 250 g and flown outside, including those flown for fun, must be registered. | *Commercial flying* | *Weight:* < 2 kg, or > 2 kg but < 25 kg if flying over your own land | *Height:* ≤ 120 m (400 ft) AGL  *Airspace:* if > 250 g fly at least 5.5 km away from a controlled airport, and not in prohibited or restrictive airspace.  *People:* ≥ 30 m from other people, and not directly over or above people, or in populous areas. This includes beaches, parks, events or sports ovals while there is a game in progress. Not over or near an area affecting public safety or where emergency operations are underway.  *Time:* daytime, and not through cloud or fog  *Sight:* Within VLOS | *Operator Accreditation*, although this is not needed if the pilot already holds a Remote Pilot Licence |
| 1) Flying for an individual or business that holds a *remotely piloted aircraft operator’s certificate (ReOC)*, or  2) Flying a drone > 25 kg but < 150 kg over your own land | 1) *Weight:* NA  2) *Weight:* > 25 kg but < 150 kg | *Remote Pilot Licence* |
| Fly in a *controlled airspace* | NA | *Aeronautical radio operators’ licence (AROC).* |
| Japan, Asia | Japan Civil Aviation Bureau (JCAB) | <https://www.mlit.go.jp/en/koku/index.html> | NA | NA | NA | *Height:* < 150 m  *People:* > 30 m between drones and people/properties on the ground/water surface.  *Built-up areas:* cannot fly above densely populated or inhabited districts.  *Airspace:* cannot fly in airspace around airports  *Time:* daytime  *Sight*: VLOS | Need permission from the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) to fly in airspace around airports, above densely inhabited districts, and ≥ 150 m above ground/sea level. |
| Algeria, Africa | Directorate of Civil Aviation and Meteorology of Algeria (DACM) | https://www.droneregulations.info/Algeria/DZ.html#country-search | Drones are banned in Algeria and will be confiscated at customs. Permission may be granted upon request. | | | | |
| South Africa, Africa | South Africa Civil Aviation Authority (SACAA) | <http://www.caa.co.za/pages/rpas/remotely%20piloted%20aircraft%20systems.aspx> | RPAS Operators Certificate and Operational Specifications | *Commercial flying* | *Weight*: ≤ 7kg | Operate in accordance with terms of Part 101 of the SACAA.  *Height:* < 45 m (150 ft) unless approved by Director of Civil Aviation of SACAA  *People:* > 50 m between drones and people.  *Built-up areas:* cannot fly ≤ 50 m from any property without permission from property owner.  *Airspace:* cannot fly ≤ 10 m from an aerodrome, near manned aircraft, or in controlled, restricted, or prohibited airspace.  *Time:* daytime  *Sight*: VLOS  *Weather:* clear weather conditions | Remote Pilot License obtained upon successful completion of RPAS training (theory, practical and Radiotelephony examination). Foreign theory training may be approved. |
| Antarctica | The Council of Managers of National Antarctic Programs (COMNAP) bring together the organisations that have the responsibility for delivering and supporting scientific research in the Antarctic Treaty Area on behalf of their respective governments and in the spirit of the Antarctic Treaty. The ‘COMNAP Remotely  Piloted Aircraft Systems Working Group (RPAS‐WG)’ focuses on the use of drones in this region. | COMNAP website: <https://www.comnap.aq/>  Relevant documents include:  1) *Wildlife Awareness Manual: Antarctic Peninsula, South Shetland Islands, South Orkney Islands. Second*  *Edition* (Harris 2021)  2) Antarctic Remotely Piloted Aircraft Systems (RPAS) Operators Handbook (COMNAP) | Usually needs to be registered in the country the researchers are from and be included on an Antarctic permit. | Flying for *scientific research*. Flying for non-research purposes is not permitted in coastal regions but is permitted by ships for navigation and away from coast and wildlife areas. | Permits may be granted for any size drone. However, most drones deployed in the Antarctic Treaty Area fall within the medium category (> 2 kg but < 25 kg), and this category is the focus of the ‘Antarctic Remotely Piloted Aircraft Systems (RPAS) Operator’s Handbook’ (COMNAP 2021) | General guidelines from the ‘Antarctic Remotely Piloted Aircraft Systems (RPAS) Operator’s Handbook’ are as follows:  *Flight pattern:* Select launch / landing sites away from wildlife and avoid overflight unless you have a permit.  *Disturbance:* Monitor any signs of wildlife disturbance and take corrective action / cease operations if necessary.  *Sight*: VLOS, unless specifically authorised otherwise. | Permit issued by an appropriate authority under Annex II to the Protocol on Environmental Protection to the Antarctic Treaty (Harris 2021). |

**Site Assessment and Permission**

**Table A3.** Example pre-site assessment form showing important information to record about the site. Useful sources of information include aeronautical chats, Google Earth, SkyVector, SkyDemon and NOTAMS.

|  |  |
| --- | --- |
| **Planned survey date** |  |
| **Survey objectives** |  |
| **Assessment of:** | **Notes** |
| 1. **Landscape** | |
| Terrain type (e.g., farmland, marsh, sand) |  |
| Landscape features (that could impair visibility of objects of interest in images) |  |
| Land ownership, including any sensitivities (e.g., nature reserve, military) |  |
| Environmental regulations |  |
| Tide table (for island access) |  |
| 1. **Airspace** | |
| Airspace classification (e.g., class A, G, etc.) |  |
| Other nearby airspace users (e.g., airfield, hot air balloon) |  |
| 1. **Access** | |
| Public access (e.g., public footpaths, bridleways) |  |
| Vehicle access (e.g., members of public, emergency services) |  |
| 1. **Physical obstructions** | |
| Buildings (e.g., residential, recreational, commercial, industrial) |  |
| Pylons |  |
| Vegetation (e.g., trees) |  |
| 1. **Weather** | |
| Forecast 24 hours prior to survey |  |
| 1. **Other** | |
|  |  |
|  |  |
| **Contact Information** | **Phone number** |
| Local Air Traffic Control |  |
| Local police |  |
| Landowner |  |
| Other |  |

**Disturbance Mitigation**

**Table A4.** Summary of 72 studies, separated into 132 sub-studies, which measured seabird responses to drones. A single study (e.g., peer-reviewed journal article) can have contributed multiple table rows (termed a ‘sub-study’) for example, by measuring different species’ and/or life-history stage responses, with different drone specifications and/or flight parameters. B = base, L = length, H = height, D = diagonally; TOLP = take-off and landing position; ‘NA’ if information not recorded in the study.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Species traits** | | | **Drone specification** | | **Flight** | | | | | **Results** | | | | **Source and Location** |
| **Species** | **Life-history stage** | **Assemblage** | **Type & engine** | **Size**  **B x L x H or D (cm)** | **Flight pattern** | **Distance from birds (m)** | **TOLP (m)** | **Speed (m/s)** | **Targeted disturbance study?** | **Behavioural response?** | **Physiological response?** | **Response to sound?** | **Summary** |
| Spheniscidae | | | | | | | | | | | | | | |
| Gentoo Penguin *Pygoscelis papua* | Breeding | Colony | 8-copter, electric (HiSystems, MK ARF Okto XL) | 73x73x36 | Horizonal & vertical | Vertical: 10-50 | 25-35 | 6.1 | Yes  Recorded behavioural response (comfort behaviours and resting; vigilance; agonistic; escape) from videos. | Yes | NA | NA | Drone noticed with 30 m take-off distance and at 50 m altitude, but strong increase in response at 15-20 m altitude. Vertical flights below 20m created more disturbance than horizontal flights. Take-off distance must be > 30 m and altitude > 50 m to exclude any disturbance. | Mustafa *et al.* 2017. Ardley  Island, Withem Island and Narebski Point, South Shetland Islands. |
| Breeding | Colony | 6-copter, electric (Aerial Imaging Solutions, APH-22) | L82.3 | Lawn-mower | Vertical: 15-60 | > 100 | NA | No | No | NA | No | No signs of disturbance at 30-60 m. Drone sounds not detected above ambient noise levels at 30 m. | Goebel *et al.* 2015. Cape Shirreff, Livingston Island, South Shetland Islands. |
| Breeding | Colony | 8-copter, electric (HiSystems, MK ARF Okto XL) | 73x73x36 | Horizontal, vertical, habituation & take-off | Vertical: 10-50 | 5-50 | Horizontal flights: 6  Vertical descent: 3  Take-off ascent: 3 | Yes  Recorded behavioural response (comfort: resting; vigilance; agonistic; escape) from videos. Repeated flight schemes three times to assess short-term habituation. | Yes | NA | NA | Clear response from 30 m downwards for horizontal & vertical flights. Marked increase in response at 20 m for vertical flights. Vertical flights below 20 m created more disturbance than horizontal flights. Possible response at take-off distance of 30 m, but became significant at 5-15 m.  No habituation to vertical flights; habituation at 25 m and 10 m altitude for horizontal flights. | Rümmler *et al*. 2018. Ardley Island, South Shetland Islands. |
| Breeding | Colony | 4-copter, electric (DJI Phantom 4 Pro) | D35 | Lawn-mower | Vertical: 35 | ≥ 30 | NA | Yes  Observer recorded behavioural responses | Yes | NA | NA | Only minor behavioural responses observed. No breeding birds left their nests. Some head-turning at edge of colonies when landing 30 m away. | Dunn *et al.* 2021. Signy Island, South Orkney  Islands. |
| Breeding | Colony | 6-copter, electric | NA | Lawn-mower | Vertical: 30 | NA | 5 | No | No | NA | NA | Remained on nests. | Ratcliffe *et al.* 2015. Volunteer Point, East Falkland. |
| Breeding | Colony | 4-copter, electric (DJI Phantom 4) | D35 | NA | Vertical: ≥ 15  Note: “greater caution was used when operating the drone at flying seabird colonies” but specific details not provided. | ≥ 15 | NA | No | No | NA | NA | Birds were aware of the drone but no evidence of disturbance to breeding birds. | Crofts & Stanworth 2020. Falkland Islands. |
| Breeding | Colony | 4-copter, electric (DJI Phantom 4 Pro V2) | D35 | NA | Vertical: ≥ 30 | NA | 3 | No | No | NA | NA | No response observed. | Wethington *et al.* 2023. Antarctic Peninsula. |
| Adélie Penguin  *Pygoscelis adeliae* | Breeding | Colony | 8-copter, electric (HiSystems, MK ARF Okto XL) | 73x73x36 | Horizontal & vertical | Vertical: 10-50 | 50 | 6.1 | Yes  Recorded behavioural response (comfort behaviours and resting; vigilance; agonistic; escape) from videos. | Yes | NA | NA | Drone noticed with 50 m take-off distance, and flown at 50 m altitude, but strong increase in response at 15-20 m altitude. Vertical flights below 20 m created more disturbance than horizontal flights. Take-off distance must be > 30 m and altitude > 50 m to exclude any disturbance. | Mustafa *et al.* 2017. Ardley  Island, Withem Island and Narebski Point, South Shetland Islands. |
| Breeding | Colony | Fixed-wing, electric (senseFly eBee) | 96 wingspan | Transects | Vertical: 85 | 50 | NA | No | No | NA | NA | No disturbance recorded. | Bird *et al.* 2020. Avian Island & Torgersen Island, Western Antarctic Peninsula. |
| Breeding | Colony | 8-copter, electric (HiSystems, MK ARF Okto XL) | 73x73x36 | Horizontal, vertical, habituation | Vertical: 10-50 | 5-50 | Horizontal flights: 6  Take-off ascent: 3 | Yes  Recorded behavioural response (comfort: resting; vigilance; agonistic; escape) from videos. Repeated flight schemes three times to assess short-term habituation. | Yes | NA | NA | Clear response from 50 m downwards for horizontal & vertical flights. Marked increase in response at 10 m for horizontal and 15 m for vertical flights. Vertical flights below 20 m created more disturbance than horizontal flights. No habituation for vertical flights; habituation at 15 m, 40 m and 50 m altitude for horizontal flights. | Rümmler *et al*. 2018. Ardley Island, South Shetland Islands. |
| Breeding | Colony | 8-copter, electric (HiSystems, MK ARF Okto XL) | 73x73x36 | Horizontal, vertical & habituation | Vertical: 10-50 | 50 | NA | Yes  Recorded behavioural response (comfort: resting; vigilance; agonistic; escape) from videos. Repeated flight schemes two times to assess short-term habituation. | Yes | NA | NA | Clear response from 20-50 m altitude, which increased markedly below 20 m. Vertical flights below 20 m created more disturbance than horizontal flights. No habituation to horizontal flights at 10 m altitude. Habituation to vertical flights was not tested. | Rümmler *et al*. 2016. Ardley Island, South Shetland Islands. |
| Breeding | Colony | Fixed-wing, fuel (CryoWing Mk1) | D380 | Lawn-mower | Vertical: 350 | 500 | NA | Yes  Recorded disturbance level (resting; comfort; vigilance/anxiety; aggression; escape) from video camera at edge of colony. | Yes | NA | NA | Short vigilance (≤ 9 seconds) by 80% of birds when directly overhead at 350 m. Similar response to when a skua flying overhead but not attacking. No birds abandoned nests. | Korczak-Abshire *et al.* 2016. Penguin Island and Turret Point Oasis, South Shetland Islands. |
| Breeding | Colony | Fixed-wing, electric (Skywalker X-8) | D210 | Lawn-mower | Vertical: 350 | 500 | NA | Yes  Recorded disturbance level (resting; comfort; vigilance/anxiety; aggression; escape) from video camera at edge of colony. | No | NA | NA | Not recognized at 350 m. | Korczak-Abshire *et al.* 2016. Penguin Island and Turret Point Oasis, South Shetland Islands. |
| Breeding | Colony | 4-copter, electric (DJI Phantom 4 Pro V2) | D35 | NA | Vertical: ≥ 30 | NA | 3 | No | No | NA | NA | No response observed. | Wethington *et al.* 2023. Antarctic Peninsula. |
| Breeding | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Transects | Vertical: 50-60 | NA | 5 | No | No | NA | NA | Minimal disturbance to wildlife. Specific details on penguin responses not provided. | Dickens *et al.* 2021. Thule Island, South Sandwich Islands. |
| Chinstrap Penguin Pygoscelis *antarctica* | Breeding | Colony | 4-copter, electric (DJI Phantom 4 Pro) & 2-copter, electric (DJI Inspire 2) | 4-copter: D35  2-copter: D60.5 | Lawn-mower | Vertical: 35 | ≥ 30 | NA | Yes  Observer recorded behavioural responses. | Yes | NA | NA | Only minor behavioural responses observed. No breeding birds left their nests. Some head-turning at edge of colonies when landing drone 30 m away. | Dunn *et al.* 2021. Signy Island, South Orkney  Islands. |
| Breeding | Colony | 4-copter &  6-copter, electric (Aerial Imaging Solutions, APH-22) | L82.3 | Lawn-mower | Vertical: 15-60 | >100 | NA | No | No | NA | No | No signs of disturbance at 30-60 m. Drone sounds not detected above ambient noise levels at 30 m. | Goebel *et al.* 2015. Cape Shirreff, Livingston Island, South Shetland Islands. |
| Breeding | Colony | 6-copter, electric (Aerial Imaging Solutions, APH-22) | L82.3 | Horizontal & Vertical | Vertical: 8-46 | 55-120 | 3-4 | Yes  Recorded disturbance level (resting; awake; looking; orientation change; escape) from video camera at edge of colony. | Yes | NA | No | No response to horizontal overhead flights at 30 m or hovering above colony at 30 m and 46 m. Behavioural reaction significantly higher at 8 m and 15 m hovering. Behavioural reaction higher when guarding chicks or moulting, compared to incubating. Escape response only evident for low-altitude flights during moult-stage. | Krause *et al.* 2021. Cape Shirreff, Livingston Island, South Shetland Islands. |
| Breeding | Colony | 4-copter, electric (DJI Phantom 4) | D35 | NA | Vertical: 25-40 | NA | NA | No | No | NA | No | No disturbance observed. Noise levels low enough that at 30 m the drone cannot be distinguished from background environmental noises at penguin colonies. | Liu *et al.* 2020. Elephant Island, Low Island, Snow Island and Anvers Island, Antarctica. |
| Breeding | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Transects | Vertical: 50-60 | NA | 5 | No | No | NA | NA | Minimal disturbance to wildlife. Specific details on penguin responses not provided. | Dickens *et al.* 2021. Thule Island, South Sandwich Islands. |
| King Penguin *Aptenodytes patagonicus* | Breeding adult | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Lawn-mower | Vertical: 2-50 | ≥ 100 | 2 | Yes  Recorded disturbance level (0=resting; 1=vigilance; 2=take a look at the drone, 3=agonistic, 4=escape) from drone videos. Measured heart rate. | Yes | Yes | NA | Minor behavioural response at 25 m and change in heart rate. | Weimerskirch *et al.* 2018. Possession Island, Crozet Islands. |
| Non-breeding adult | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Lawn-mower | Vertical: 2-50 | ≥ 100 | 2 | Yes  Recorded disturbance level (0=resting; 1=vigilance; 2=take a look at the drone, 3=agonistic, 4=escape) from drone videos | Yes | NA | NA | Clear response at 25 m. | Weimerskirch *et al.* 2018. Possession Island, Crozet Islands. |
| Chicks | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Lawn-mower | Vertical: 2-50 | ≥ 100 | 2 | Yes  Recorded disturbance level (0=resting; 1=vigilance; 2=take a look at the drone, 3=agonistic, 4=escape) from drone videos. Measured heart rate. | Yes | Yes | NA | Behavioural response at 50 m, heart rate increased at 25 m. | Weimerskirch *et al.* 2018. Possession Island, Crozet Islands. |
| Non-breeding | Solitary | 6-copter, electric | NA | Lawn-mower | Vertical: 30 | NA | 5 | No | Yes | NA | NA | At 30 m walked away. | Ratcliffe *et al.* 2015. Volunteer Point, East Falkland. |
| Breeding | Colony | Kite (Ricoh IV GR carried on string of single-line delta kite with a home-made tilting platform T-suspension system) | 200x160 | Flown over colony, by kite operator moving the kite to get different views. | Vertical: 150-250 | 20-30 | NA | No | No | NA | NA | No response observed during flights. Vigilance behaviour by a few birds during take-off and as the kite ascended 20-30 m high due to noise produced by the kite. | Delord *et al.* 2015. Kerguelen, Southern Indian Ocean. |
| Breeding | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Transects | Vertical: 50-100 | NA | 5 | No | No | NA | NA | Minimal disturbance to wildlife. Specific details on penguin responses not provided. | Dickens *et al.* 2021. St Andrews Bay, South Georgia. |
| Macaroni penguin *Eudyptes chrysolophus* | Breeding | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Lawn-mower | Vertical: 2-50 | ≥ 100 | 2 | Yes  Recorded disturbance level (0=resting; 1=vigilance; 2=take a look at the drone, 3=agonistic, 4=escape) from drone videos | Yes | NA | NA | Slight response at 25 m. | Weimerskirch *et al.* 2018. Possession Island, Crozet Islands. |
| Breeding | Colony | Kite (GoPro Hero 3 carried on string of single-line delta kite with a home-made tilting platform T-suspension system) | 200x160 | Flown over colony, by kite operator moving the kite to get different views. | Vertical: 150-250 | 20-30 | NA | No | No | NA | NA | No response observed during flights. Vigilance behaviour by a few birds during take-off and as the kite ascended (20-30 m high due to noise produced by the kite. | Delord *et al.* 2015. Kerguelen, Southern Indian Ocean. |
| Breeding | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Transects | Vertical: 50-100 | NA | 5 | No | No | NA | NA | Minimal disturbance to wildlife. Specific details on penguin responses not provided. | Dickens *et al.* 2021. Rookery Bay, South Georgia. |
| Southern rock-hopper penguin *Eudyptes chrysocome* | Breeding | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Lawn-mower | Vertical: 2-50 | ≥ 100 | 2 | Yes  Recorded disturbance level (0=resting; 1=vigilance; 2=take a look at the drone, 3=agonistic, 4=escape) from drone videos | Yes | NA | NA | Slight response at 25 m. | Weimerskirch *et al.* 2018. Possession Island, Crozet Islands. |
| Breeding | Colony | 4-copter, electric (DJI Phantom 4) | D35 | NA | Vertical: ≥ 15  Note: “greater caution was used when operating the drone at flying seabird colonies” but specific details not provided. | ≥ 15 | NA | No | No | NA | NA | Birds were aware of the drone but no evidence of disturbance to breeding birds. | Crofts & Stanworth 2020. Falkland islands. |
| Royal Penguin Eudyptes *schlegeli* | Moulting | Colony | Fixed-wing (custom built with HornbillSurveys.com, FX79 airframe) | NA | Lawn-mower | Vertical: 120 | NA | 13 | No  Observers looked for group startle response, as bird taking flight would affect colony counts. | No | NA | NA | No group startle response observed at 120 m. | Hodgson *et al.* 2016. Macquarie Island, Australia. |
| Erect-crested Penguin *Eudyptes sclateri* | Breeding | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Lawn-mower | Vertical: 40-80 | NA | NA | No | No | NA | NA | No visible response. Black-backed Gulls *Larus dominicanus* occasionally circled airborne drone, but no direct interactions. | Mattern *et al.* 2021. Bounty Islands. |
| Breeding & Loafing | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Hover & transects | Launch & hover at: 5, 10, 15, 20, 40, 60, or 80 m.  Horizontal transects: 40, 60 and 80 m. | NA | NA | Yes  Observed and, where possible, video recorded responses during two stages:  1. Vertical launch/landing (slow or fast, rising to 5, 10, 15, 20, 40, 60, or 80 m before hovering in place)  2. Horizontal overflight at 40, 60 and 80 m  place | Yes | NA | NA | Launch/landing: Birds on the ground (nesting or loafing) near launch/landing showed little response. Penguins within 5 m cocked their heads but with little shift in body position. Drone largely ignored once above 5 m.  Horizontal transects: Horizontal flight at 40, 60 and 80 m got reactions only from gulls. | Rexer-Hueber & Parker 2020. Bounty Islands, New Zealand. |
| Emperor Penguin *Aptenodytes forsteri* | Breeding adult | Colony | 4-copter, electric (DJI Phantom 4 Pro) | 38x22x32 | 1) Horizontal overpasses at 20 m, repeated 3x  2) Descended from 100 m to 15 m altitude at 1 m/s  3) Ascended from 15 m to 100 m altitude and hovered at 100 m for 3 minutes/until obvious behavioural reaction ended | Vertical: 15 to > 100 | ≥ 100 | Horizontal: 5  Vertical: 1 | Yes  Recorded disturbance response (flipper-flapping; vigilance; sleeping; undefined) from videos, and compared for undisturbed controls, human approach, vertical drone approach and horizontal overflights. | Yes | NA | NA | Intermediate response to vertical drone approach, few reactions to horizontal overflights. | Rümmler *et al*. 2021a. Atka Bay, Antarctic continent. |
| Chicks | Colony | 4-copter, electric (DJI Phantom 4 Pro) | 38x22x32 | 1) Horizontal overpasses at 20 m, repeated 3x  2) Descended from 100 m to 15 m altitude at 1 m/s  3) Ascended from 15 m to 100 m altitude and hovered at 100 m for 3 minutes/until obvious behavioural reaction ended | Vertical: 15 to > 100 | ≥ 100 | Horizontal: 5  Vertical: 1 | Yes  Recorded disturbance response (flipper-flapping; vigilance; sleeping; undefined) from videos, and compared for undisturbed controls, human approach, vertical drone approach and horizontal overflights. | Yes | NA | NA | Increased vigilance during all drone activity, but greatest reaction to vertical drone approach. | Rümmler *et al*. 2021a. Atka Bay, Antarctic continent. |
| Breeding adults | Colony | 4-copter, electric (DJI Phantom 4 Pro) and fixed-wing, electric (Magpy, MAPIR) | 4-copter: 38x22x32  Fixed-wing: 86.4×58.4×14 | Horizontal overpasses | Vertical: 20 - 145 | NA | NA | Yes  Recorded disturbance response (flipper-flapping; vigilance; sleeping; moving; undefined) from videos, and compared for undisturbed controls, investigating influence of drone height, type (multi-rotor or fixed-wing), and investigation day. | Yes | NA | NA | 1. Flight height   Multi-rotor: No significant difference in proportion of vigilant adults at ≥ 45 m height compared to controls; but significantly more flipper-flapping adults at ≤ 70 m. Concluded that flight height > 70 m above adults causes no disturbance during this breeding stage.  Fixed-wing: Significantly more vigilant adults at 90 m flight height compared to controls; but no significant difference at lower flight heights (70, 45, and 30 m).  Flight height not regularly associated with proportion of sleeping individuals, suggesting flights do not impose enough disturbance to wake them up in larger groups. No strong significant association between flight height and proportion of moving individuals.   1. Type   Reaction to multi-rotor stronger than fixed-wing, perhaps due to it being noisier. | Rümmler *et al*. 2021b. Atka Bay, Antarctic continent. |
| Chicks | Colony | 4-copter, electric (DJI Phantom 4 Pro) and fixed-wing, electric (Magpy, MAPIR) | 4-copter: 38x22x32  Fixed-wing: 86.4×58.4×14 | Horizontal overpasses | Vertical: 20 - 145 | NA | NA | Yes  Recorded disturbance response (flipper-flapping; vigilance; sleeping; moving; undefined) from videos, and compared for undisturbed controls, investigating influence of drone height, type (multi-rotor or fixed-wing), and investigation day. | Yes | NA | NA | 1. Flight height   Multi-rotor: Significantly more vigilant and flipper-flapping chicks at all flight heights compared to controls.  Fixed-wing: Significantly more vigilant chicks at 45, 70, and 90 m flight heights compared to controls; but no significant difference at the lowest flight height, 35 m.  Flight height not regularly associated with proportion of sleeping individuals, suggesting flights do not impose enough disturbance to wake them up in larger groups. No strong significant association between flight height and proportion of moving individuals.   1. Type   Reaction to muti-rotor stronger than fixed-wing, perhaps due to it being noisier.   1. Day   Greater impact of multi-rotor on second day (i.e. older chicks). | Rümmler *et al*. 2021b. Atka Bay, Antarctic continent. |
| Yellow-eyed Penguin *Megadyptes antipodes* | Breeding | Colony | 4-copter, electric (SteadiDrone) |  | Lawn-mower | Vertical: 30, 40, 50 | NA | NA | No | No | NA | NA | Minimal disturbance. | Muller *et al.* 2019 |
| Procellariidae | | | | | | | | | | | | | | |
| Southern Giant Petrel *Macronectes giganteus* | Breeding | Small group | 4-copter, electric (DJI Phantom 3) | D35 | Lawn-mower | Vertical: 2-50 | ≥ 100 | 2 | Yes  Recorded disturbance level (0=resting; 1=vigilance; 2=take a look at the drone, 3=agonistic, 4=escape) from drone videos | Yes | NA | NA | Clear response at 50 m. | Weimerskirch *et al.* 2018. Possession Island, Crozet Islands. |
| Breeding | Colony | 4-copter, electric (DJI Phantom 4) | D35 | NA | Vertical: ≥ 15  Note: “greater caution was used when operating the drone at flying seabird colonies” but specific details not provided. | ≥ 15 | NA | No | No | NA | NA | Birds were aware of the drone but no evidence of disturbance to breeding birds. | Crofts & Stanworth 2020. Falkland Islands. |
| Breeding | Colony | 4-copter, electric (DJI Inspire 2) | D60.5 | Lawn-mower | Vertical: 30-200 | ≥ 100 | 4 | Yes  Ground observer made behavioural observations pre-flight and during flight, at five different heights (130, 100, 70, 50 and 30 m). Observations separated into two groups: 1) change in location of individual and 2) behavioural responses to a change in drone flight height. Response behaviours were recorded as: no change in position or started to rest (0), interrupted rest (1), flew to the colony (2), left the colony (3). | Yes | NA | NA | Number of adults that flew away from the colony did not significantly differ before flight and during flight. Behavioural responses of adults and chicks to all height changes did not significantly differ from control results, but there was:  - An increase in interrupted rest (1) from 50 to 30 m, although the most frequent behaviour was still ‘no change’ or ‘starting rest’ (0) for all height changes.  - Significant difference in adult position from 50 to 30 m.  Overall, no obvious behavioural signs of disturbance during flights and no significant behavioural changes (e.g. changes in bird location) when flight altitude was lowered. | Fudala & Bialik 2022. Admiralty Bay, King George Island |
| Northern giant petrel *Macronectes halli* | Non-breeding | Small group | 4-copter, electric (DJI Phantom 3) | D35 | Lawn-mower | Vertical: 2-50 | ≥ 100 | 2 | Yes  Recorded disturbance level (0=resting; 1=vigilance; 2=take a look at the drone, 3=agonistic, 4=escape) from drone videos | Yes | NA | NA | Slight response at 50 m. | Weimerskirch *et al.* 2018. Possession Island, Crozet Islands. |
| Diomedeidae | | | | | | | | | | | | | | |
| Wandering albatross *Diomedea exulans* | Non-breeding, fledglings | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Lawn-mower | Vertical: 2-50 | ≥ 100 | 2 | Yes  Recorded disturbance level (0=resting; 1=vigilance; 2=take a look at the drone, 3=agonistic, 4=escape) from drone videos | Yes | NA | NA | Clear response at 50 m. | Weimerskirch *et al.* 2018. Possession Island, Crozet Islands. |
| Breeding | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Transects | Vertical: 120 | NA | 5 | No | No | NA | NA | Minimal disturbance to wildlife. Specific details on albatross responses not provided. | Dickens *et al.* 2021. Bay of Isles, South Georgia. |
| Sooty albatross *Phoebetria fusca* | Breeding | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Lawn-mower | Vertical: 2-50 | ≥ 100 | 2 | Yes  Recorded disturbance level (0=resting; 1=vigilance; 2=take a look at the drone, 3=agonistic, 4=escape) from drone videos | Yes | NA | NA | Slight response at 25 m. | Weimerskirch *et al.* 2018. Possession Island, Crozet Islands. |
| Light-mantled sooty albatross *Phoebetria palpebrata* | Breeding | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Lawn-mower | Vertical: 2-50 | ≥ 100 | 2 | Yes  Recorded disturbance level (0=resting; 1=vigilance; 2=take a look at the drone, 3=agonistic, 4=escape) from drone videos | Yes | NA | NA | Clear response at 25 m. | Weimerskirch *et al.* 2018. Possession Island, Crozet Islands. |
| Tristan Albatross *Diomedea dabbenena* | Breeding | Colony | 4-copter, electric (DJI Phantom 2) | D35 | Transect | Vertical: 20-150 | NA | 5 | No | No | NA | NA | No response observed. | McClelland *et al.* 2016. Inaccessible Island, Tristan da Cunha. |
| Campbell Albatross Thalassarche *impavida* | Breeding | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Lawn-mower | Vertical: ≥ 150 | NA | NA | No  Observer monitored response with binoculars | No | NA | NA | No response observed. | Rexer-Huber *et al.* 2020. Campbell Island, New Zealand. |
| Grey-headed Albatross Thalassarche *chrysostoma* | Breeding | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Lawn-mower | Vertical: ≥ 150 | NA | NA | No  Observer monitored response with binoculars. | No | NA | NA | No response observed. | Rexer-Huber *et al.* 2020. Campbell Island, New Zealand. |
| Black-browed Albatross *Thalassarche melanophris* | Breeding | Colony | 4-copter, electric (DJI Phantom 4) | D35 | NA | Vertical: ≥ 15  Note: “greater caution was used when operating the drone at flying seabird colonies” but specific details not provided. | ≥ 15 | NA | No | No | NA | NA | Birds were aware of the drone but no evidence of disturbance to breeding bird. | Crofts & Stanworth 2020. Falkland Islands. |
| Salvin’s Albatross *Thalassarche salvini* | Breeding & Loafing | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Hover & transects | Launch & hover at: 5, 10, 15, 20, 40, 60, or 80 m.  Horizontal transects: 40, 60 and 80 m. | NA | NA | Yes  Observed and, where possible, video recorded responses during two stages:  1. Vertical launch/landing (slow or fast, rising to 5, 10, 15, 20, 40, 60, or 80 m before hovering in place)  2. Horizontal overflight at 40, 60 and 80 m  place | Yes | NA | NA | Launch/landing: Birds on the ground (nesting or loafing) near launch/landing showed little response. Albatrosses within 5 m cocked their heads but with little shift in body position. Drone largely ignored once above 5 m.  Horizontal transects: Horizontal flight at 40, 60 and 80 m got reactions only from gulls. | Rexer-Hueber & Parker 2020. Bounty Islands, New Zealand. |
| White-capped albatross *Thalassarche cauta steadi* | Breeding & Loafing | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Hover & transects | Vertical: 30 | NA | NA | Yes  DSLR camera video recorded responses during two stages:  1. Launch and ascent (careful and slow launch and hover then slow ascent to 30 m flight height)  2. Overflight (initial hover at target flight height then if no reaction, slow flight in a steady and straight transect). | Yes | NA | NA | Minimal response when launching/landing. Albatrosses on the ground (nesting/loafing) watched the drone closely when it was launching/landing but did not move, and ignored the drone when it was > 5 m, including overflight at 30 m.  Albatrosses in flight were visibly aware of the drone and avoided it.  Some seabirds approached within 10-20 m, but then kept on going (Northern Giant Petrel) or followed at a distance (White-chinned Petrels). Skuas were present but did not come to investigate the drone. | Parker et al. 2022. Auckland Islands, New Zealand. |
| Phalacrocoracidae | | | | | | | | | | | | | | |
| Phalacrocoracidae spp. | NA | Individuals/groups | 4-copter, electric (DJI Phantom 2 Vision+, Inspire 1, and Phantom 4) | Phantom 2: D35; Inspire 1: D57.9;  Phantom 4: D35  INCLUDE VISION+ | Lawn-mower | Vertical: not specified, but did fly < 25 m and > 30 m | NA | NA | No  Observations made from drone video footage. | Yes | NA | NA | No disturbance at 30 m height. Most waterbirds in the study disturbed at < 25 m; flew into the air or moved quickly over the surface. | Han *et al.* 2017. Upo wetland, Korea. |
| Imperial Cormorant *Leucocarbo atriceps* | Breeding | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Lawn-mower | Vertical: 2-50 | ≥100 | 2 | Yes | Yes | NA | NA | Slight response at 50 m. | Weimerskirch *et al.* 2018. Possession Island, Crozet Islands. |
| Breeding | Colony | 4-copter, electric (DJI Phantom 3) | D35 | NA | Vertical: 20-80 | NA | NA | No | No | NA | NA | No flight/disturbance response observed. | Yorio et al. 2020. Chubut coastline, Argentina. |
| Pied Cormorant *Phalacrocorax varius* | NA | NA | 4-copter, electric (DJI Phantom 3) | D35 | Drone approached individual birds and single-species groups. Approach ended when response occurred, or drone passed overhead. | Vertical: 10 | 76.9 ± 6.9 | 2.22 | Yes  Recorded whether the individual or nearest bird (for small groups) showed an escape response (walk, run, fly). Recorded alert distance (AD) and calculated flight-initiation distance (FID) if escape response shown. | Yes | NA | Yes | High (10 m) flight height: alert distance = 47.6 ± 12.04 m; FID = 9.0 ± 0.63m; 20.0% no response; 75.0% fly response; 25.0% walk response. | Weston *et al.* 2015. Central southern Victoria, Australia. |
| Guanay Cormorant Phalacrocorax *bougainvilli* | Breeding & Non-breeding | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Horizontal & Vertical | Vertical: 5-100 | 100 | 0.5-3 vertically  0.5-15 horizontally | Yes  Recorded disturbance level (0=no reaction; 1=head pointing; 2=wing flapping; 3=walking/running; 4=taking-off/flying). Recorded drone noise at different altitudes using sound meter close to colony to discriminate visual and auditory drone effects. | Yes | NA | No | Only flight altitude affected intensity of reaction; vertical and horizontal speed did not. No reaction at > 50 m altitude. More frequent reactions at 5-10 m altitude, although chick-rearing cormorants were less sensitive than non-breeding cormorants between 5-30 m. Background colony noise was as loud as the drone. | Irigoin-Lovera *et al.* 2019. Lobos de Tierra, Macabí, Guañape  Norte, Guañape Sur, Mazorca, Pescadores, Asia, Chincha Centro and Chincha Sur y Ballestas  Norte, Peru. |
| Breeding | Colony | Kite (Canon Powershot G11 carried on the string of a single-line rokkaku kite using Picavet suspension rig) | 200x160 | Flown over colony, by kite operator moving the kite to get different views. | Vertical: 150-250 | 20-30 | NA | No | No | NA | NA | No response observed during flights. Vigilance behaviour by a few birds during take-off and as the kite ascended (20-30 m high due to noise produced by the kite. | Delord *et al.* 2015. Isla Pescadores, Peru. |
| Pelagic *Phalacrocorax pelagicus* and Double-crested Cormorant *Phalacro-corax auratus* | Breeding | Colony | 4-copter, electric (DJI Inspire 2 and DJI Mavic Air) | Large (Inspire 2): D60.5  Small (Mavic Air): D21.3 | NA | Close: 30 horizontal, 45 altitude  Far: 60 horizontal, 75 altitude | From a boat. Distance at drone launch not specified, but boat remained 122 – 889 m from colony during drone surveys. | Slow: 2  Fast: 8 | Yes  Video recorded 12-20 birds and made behavioural observations pre-flight (10 mins before take-off), during flight (range 3-15 mins), and post-flight (10 mins after landing. Response behaviours were recorded as: flushing, alert, alert head bobbing, and out of sight post-flush. | No | NA | NA | No flushes observed. Birds spent more time ‘Out of Sight post-flush’ (OSP) during and post-flight compared to pre-flight for the fast, close, and large drone flight, but this was not significant. | Bishop *et al.* 2022. Beehive Islands, Gulf of Alaska. |
| Great Cormorant *Phalacrocorax carbo sinensis* | Foraging | Individuals/group | 4-copter, electric (DJI Phantom 4 and DJI M300) | Phantom 4: D35  M300: D895 | NA | Vertical: ≤ 30 | NA | NA | No | Yes | NA | NA | No response at > 10 m height. At < 10 m cormorants moved by several metres and if the drone was kept here for several minutes the cormorants left the pond, returning 20 mins after drone removal. | Polensky *et al.* 2022. South Bohemia, Czech Republic. |
| Reed Cormorant *Microcarbo africanus* & White-breasted Cormorant *Phalocrocorax lucidus* | Breeding | Colony | 4-copter, electric (DJI Phantom 4 Advanced) | D35 | Transects | Vertical: 16-120 | NA | 2 | No  Started at 25 m flight height and explored appropriate heights to allow for identification of birds and nest contents while observing if nesting birds were disturbed. | No | NA | NA | Most birds remained undisturbed at 16 m above the riverbank. | Francis *et al.* 2022. Chobe River, Botswana. |
| Antarctic Shag *Leucocarbo bransfieldensis* | Breeding | Colony | 4-copter, electric (DJI Phantom 4 Advanced) | D35 | NA | Vertical: 90 | NA | NA | No | No | NA | NA | No response observed. | Oosthuizen *et al.* 2020. Harmony Point, Nelson Island, South Shetland Islands. |
| South Georgia Shag *Leucocarbo atriceps georgianus* | Breeding | Colony | 4-copter, electric (DJI Phantom 4 Pro) & 2-copter, electric (DJI Inspire 2) | 4-copter: D35  2-copter: D60.5 | Lawn-mower | Vertical: 50 | ≥ 30 | NA | Yes  Observer recorded behavioural responses. | Yes | NA | NA | Only minor behavioural responses observed. No breeding birds left their nests. | Dunn *et al.* 2021. Signy Island, South Orkney  Islands. |
| Foveaux shag *Leucocarbo stewartia* & Otago shag *Leucocarbo chalconotus* | Non-breeding | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Hover & transects | Vertical: 50-10 | NA | NA | Yes  DSLR camera video recorded responses during two stages:  1. Launch and ascent (careful and slow launch and hover then slow ascent to 50 m flight height)  2. Overflight (initial hover at target flight height then if no reaction, slow flight in a steady and straight transect). Overflight height  decreasing in 10 m steps from initial 50 m, until change in behaviour observed. | Yes | NA | NA | Response varied for different colonies, but in general, shags tolerated slow overflight at 20m. (i.e. responses included no reaction, alert postures, a few Otago shags took flight but landed after 15 seconds). Flight abandoned at 15 m over Otago Shags (and not tried over Foveaux shag), as birds looked agitated, mass movement (walking but still not running or flying) and about to take flight. | Parker & Rexer-Hueber 2021. Oamaru  Harbour, Pukekura / Taiaroa Head, Whero Rock, and Kanetetoe Island, New Zealand. |
| Spotted Shag *Phalacrocorax punctatus* | Non-breeding | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Hover & transects | Vertical: 50-10 | NA | NA | Yes  DSLR camera video recorded responses during two stages:  1. Launch and ascent (careful and slow launch and hover then slow ascent to 50 m flight height)  2. Overflight (initial hover at target flight height then if no reaction, slow flight in a steady and straight transect). Overflight height  decreasing in 10 m steps from initial 50 m, until change in behaviour observed. | Yes | NA | NA | Response varied for different colonies, but in general, shags tolerated slow overflight at 20 m. (i.e. responses included no reaction, alert postures). At 15 m Spotted Shags alert but not moving. | Parker & Rexer-Hueber 2021. Oamaru  Harbour, Pukekura / Taiaroa Head, Whero Rock, and Kanetetoe Island, New Zealand. |
| European Shag *Gulosus aristotelis* | Breeding | Colony | 4-copter, electric (DJI Mavic 2 Enterprise Advanced) | D354 | Lawn-mower | Vertical: 60-70 | 50 | < 3 | No | No | NA | NA | No breeding birds left their nests. | T. Hart & A. Edney pers. comm. Isle of May, Scotland. |
| Sulidae | | | | | | | | | | | | | | |
| Peruvian Booby Sula *variegata* | Breeding & Non-breeding | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Horizontal & Vertical | Vertical: 5-100 | 100 | 0.5-3 vertically  0.5-15 horizontally | Yes  Recorded disturbance level (0=no reaction; 1=head pointing; 2=wing flapping; 3=walking/running; 4=taking-off/flying). Recorded drone noise at different altitudes using sound meter close to colony to discriminate visual and auditory drone effects. | Yes | NA | No | Only flight altitude affected intensity of reaction; vertical and horizontal speed did not. No reaction at > 50 m altitude. More frequent reactions at 5-10 m altitude. Chick-rearing and non-breeding boobies reacted similarly. Background colony noise was as loud as the drone. | Irigoin-Lovera *et al.* 2019. Lobos de Tierra, Macabí, Guañape  Norte, Guañape Sur, Mazorca, Pescadores, Asia, Chincha Centro and Chincha Sur y Ballestas  Norte, Peru. |
| Red-footed Booby *Sula sula* | Breeding | Colony | 4-copter, electric (DJI Phantom 3 Advanced) | D35 | Overflights using DroneDeplyTM software | Vertical: 30 | NA | 5 | No | No | NA | NA | No response observed. | Espíndola *et al*., 2023. Mona Island, Puerto Rico. |
| Northern Gannet *Morus bassanus* | Breeding | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Started from boat, 370 m away from colony. Flew vertically up until 100 m above top of colony and approached colony at this height. For nests at the highest point, lowered to 50 m and surveyed in lawn-mower pattern. For nests on lower ledges, moved 50 m out to sea, and lowered to height of highest nest on stac/island (as gannets were not flying above the tip of the colony), then surveyed in lawn-mower pattern by tilting the camera up and down as the drone moved along the cliff face. Only lowered further to capture bottom ledges if gannets consistently flying much lower than drone. | Vertical: 50-100 | 370 | < 3 | No | No | NA | NA | No response observed in gannets. One skua and two juvenile gulls circled around the drone once, then lost interest and flew off. | I. Juárez- Martinez pers. comm. Stac an Armin, Stac Lee and Boreray, St Kilda, Scotland. |
| Pelecanidae | | | | | | | | | | | | | | |
| Peruvian Pelican Pelecanus *thagus* | Breeding & Non-breeding | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Horizontal & Vertical | Vertical: 5-100 | 100 | 0.5-3 vertically  0.5-15 horizontally | Yes  Recorded disturbance level (0=no reaction; 1=head pointing; 2=wing flapping; 3=walking/running; 4=taking-off/flying). Recorded drone noise at different altitudes using sound meter close to colony to discriminate visual and auditory drone effects. | Yes | NA | No | Only flight altitude affected intensity of reaction; vertical and horizontal speed had no effect. No reaction at > 50 m altitude. More frequent reactions at 5-10 m altitude, although chick-rearing pelicans were less sensitive than non-breeding cormorants between 5-30 m. Background colony noise was as loud as the drone. | Irigoin-Lovera *et al.* 2019. Lobos de Tierra, Macabí, Guañape  Norte, Guañape Sur, Mazorca, Pescadores, Asia, Chincha Centro and Chincha Sur y Ballestas  Norte, Peru. |
| Brown Pelican *Pelecanus occidentalis* | Breeding | Colony | Fixed-wing, electric (type not given) | NA | Consecutive Passes | Vertical: 40-60 | NA | NA | No | No | NA | NA | Most birds flushed during ground surveys, but none flushed during drone surveys. | Jones *et al.* 2021. Queen Bess Island, Louisiana, USA. |
| Fregatidae | | | | | | | | | | | | | | |
| Lesser Frigatebird *Fregata ariel* | Breeding | Colony | 8-copter, electric (X8 3D Robotics) | 61x61x20.3 | Lawn-mower | Vertical: 75 | > 100 | 2-3 | No  Observers looked for group startle response, as bird taking flight would affect colony counts. | No | NA | NA | No group startle response observed at 75 m. | Hodgson *et al.* 2016. Ashmore Reef Commonwealth Marine Reserve, Australia. |
| Magnificent Frigatebird *Fregata magnificens* | Breeding | Colony | 8-copter, electric (X8+ 3D Robotics) | 35x51x20 | Lawn-mower | Vertical: 80 | NA | NA | No | No | NA | NA | No response observed. | Villegas *et al.* 2018. Manglares del Morro, Equador. |
| Stercorariidae | | | | | | | | | | | | | | |
| Brown/South Polar Skua *Catharacta antarctica/C. maccormicki* | Breeding | Solitary | 4-copter, electric (DJI Phantom 3) | D35 | Lawn-mower | Vertical: 2-50 | ≥ 100 | 2 | Yes  Recorded disturbance level (0=resting; 1=vigilance; 2=take a look at the drone, 3=agonistic, 4=escape) from drone videos. | Yes | NA | NA | Clear response at 50 m. | Weimerskirch *et al.* 2018. Possession Island, Crozet Islands. |
| Laridae | | | | | | | | | | | | | | |
| Saunder’s Gull *Saundersilarus saundersi* | Breeding | Colony | 4-copter, electric (DJI Mavic Pro) | D33.5 | Line transects | Vertical: 30 | NA | 2 | No | No | NA | NA | No response observed. | Choi *et al.* 2020. Songdo, Korea. |
| Red-billed Gull *Chroicocephalus novaehollandiae scopulinus* | Non-breeding | Colony | 4-copter, electric (DJI Mavic 2 Pro) | 32.2x24.2x8.4 | Hover & transects | Vertical: 50-10 | NA | NA | Yes  DSLR camera video recorded responses during two stages:  1. Launch and ascent (careful and slow launch and hover then slow ascent to 50 m flight height)  2. Overflight (initial hover at target flight height then if no reaction, slow flight in a steady and straight transect). Overflight height  decreasing in 10 m steps from initial 50 m, until change in behaviour observed. | Yes | NA | NA | All gulls took flight at 30 m and 20 m height but landed after 10 seconds. | Parker & Rexer-Hueber 2021. Oamaru  Harbour, Pukekura / Taiaroa Head, Whero Rock, and Kanetetoe Island, New Zealand. |
| Silver Gull *Chroicocephalus novaehollandiae* | NA | NA | 4-copter, electric (DJI Phantom 3) | D35 | Drone approached individual birds and single-species groups. Approach ended when response occurred, or drone passed overhead. | Vertical: 4 and 10 | Low (4 m ) flight height: 69.5 ± 2.5  High (10 m) height: 78.3 ± 3.7 | 2.22 | Yes  Recorded whether the individual or nearest bird (for small groups) showed an escape response (walk, run, fly). Recorded alert distance (AD) and calculated flight-initiation distance (FID) if escape response shown. | Yes | NA | Yes | Low (4 m) flight height: alert distance = 29.4 ± 4.1 ; FID = 29.4 ± 4.1 m; 23.3% no response; 34.8% fly response’ 26.1% run response; 39.1% walk response.  High (10 m) flight height: alert distance = 51.0; FID = 29.5 ± 4.6 m; 25.9% no response; 30.0% fly response’ 25.0% run response; 45.0% walk response. | Weston *et al.* 2015. Central southern Victoria, Australia. |
| Black-headed Gull Chroicocephalus *ridibundus* | Breeding | Colony | Fixed-wing, electric (Multiplex Twin Star II, HiTec/Multiplex) | 142 wingspan | NA | Vertical: 30-40 | 470 | 8.3-11.1 | No  Calculated the percentage of gulls flying in each image. | No | NA | NA | No notable response, only 1.25% of gulls seen flying. | Sardà‐Palomera *et al.* 2012. Estany d’Ivars i Vila-Sana, Catalonia, USA. |
| Breeding | Colony | Fixed-wing, electric (Skywalker) | 168 wingspan | ‘Overflights’ | Vertical: 30-40 | NA | 8.3-11.1 | No | No | NA | NA | No adverse behaviours observed. | Sardà‐Palomera *et al.* 2017. Estany d’Ivars i Vila-Sana, Catalonia, USA. |
| Breeding | Colony | 4-copter, electric (DJI Mavic Pro) | D33.5 | Lawn-mower.  ‘Cautious overflight approach’ – drone flown in lawn-mower pattern at 30 m to assess nest attendance.  ‘Close-up approach’ – drone flown at 5 and 2 m altitude to detect clutches and eggs | Vertical: 2-70 | ≥ 150 | 8.3-11.1 | No  Recorded 1) duration of escape behaviour; 2) number of nests deserted and predated | Yes | NA | NA | Time spent away from nests was lower for drone surveys than for ground counts. No escape response during ‘cautious’ approach. At 2-5m drone intrusion, individuals always flew away, but quickly returned to nests (within 1.7 ± 0.6 min, range: 1.2–2.7 min).  No nest desertion or predation attempts observed during drone surveys. | Scarton & Valle 2022. Lagoon of Venice, Italy. |
| Common Gull Larus *canus* | Breeding | Colony | 4-copter, electric (MD 4 1000, Microdrones GmbH) & 8-copter (Falcon 8, Ascending Technologies) | 4-copter: L103  8-copter: 76.8x81.7x16.0 | NA | NA | NA | NA | No  Visual observation during test flights. | No | NA | NA | No panic or escape behaviour observed at distances ≥ 15 m. | Grenzdörffer 2013. Langenwerder Island, Germany. |
| Iceland Gull *Larus glaucoides* | Breeding | Colony | 4-copter, electric (DJI Phantom 4) | D35 | NA | Horizontal: 27-37 | NA | NA | No  Visual observation. | Yes | NA | NA | Alarming when drone 32 ± 5 m from cliffs. All birds returned to cliffs within 3.3 ± 1.2 mins. | Brisson‐Curadeau *et al.* 2017. Coats Island. Canada. |
| Glaucous-winged Gull *Larus glaucescens* | Breeding | Colony (urban) | 4-copter, electric (DJI Phantom 4 Pro and DJI Inspire 1) | DJI Phantom 4 Pro: D35  DJI Inspire 1: D57.9 | Lawn-mower | Vertical: 76-90 | NA | 15-20 | No  Visual observation. | No | NA | NA | No response observed. | Blight *et al.* 2019. City of Victoria, B.C., Canada. |
| Breeding | Colony (urban) | Fixed-wing, electric (senseFly eBee Plus) | 96 wingspan | Lawn-mower | Vertical: 99-122 | NA | 15-20 | No  Visual observation. | No | NA | NA | No response observed. | Blight *et al.* 2019. City of Victoria, B.C., Canada. |
| Glaucous Gull *Larus hyperboreus* | Breeding | A few nests | 4-copter, electric (DJI Phantom 4) | D35 | 1) Horizontally towards cliff-face  2) From above (drone lowered from cliff-edge above colony)  3) Approached from below (drone raised from point beneath colony)  Note, drone always took off from edge of cliff, (either 15-20 m directly above plot or 30 m further along cliff edge), and was then flown to condition 1), 2) or 3). | Horizontal: 15-30 | 1)Edge of cliff 15-20 m directly above plot from plot 2)30 m further along cliff-edge | NA | No  Behavioural response recorded opportunistically. | No | NA | NA | No response observed. | Brisson-Curadeau *et al.* 2017. Coats Island, Canada. |
| Western Gull Larus occidentalis | Breeding | Colony | 4-copter, electric (DJI Phantom 3 Standard) | D35 | Lawn-mower | 25-60 | NA | 2 | No  Recorded behavioural response (alarm, flushing, mobbing), time when first individuals flushed and return to nest, number of reacting birds. | Yes | NA | NA | Little behavioural response ≥ 50 m and no response at 60 m. | Albores-Barajas *et al.* 2018. Natividad Island, Mexico. |
| Kelp Gull *Larus dominicanus* | Unspecified | Individuals | 4-copter, electric (DJI Mavic Pro Platinum; DJI Phantom 3 Pro) | Mavic Pro: D33.5  Phantom 3 Pro: D35 | Kept above the whales as they moved | Vertical: 20 – 100 from whales | NA | NA | No | No | No | No | No response observed | Azizeh *et al.* 2021. Península Valdés, Argentina. |
| Herring Gull *Larus argentatus* | Individual | A few nests | 4-copter, electric (Spyder X8, SkyHero) | NA | Flying back to land | NA | NA | NA | No | Yes | NA | NA | Single Herring Gull *Larus argentatus* struck right front quarter with enough force to break propellers. Gull flew away apparently unharmed. Happened after passing the colony on the way back to land, about 75 m past  the colony as it few over gull nests with young chicks | Brisson‐Curadeau *et al.* 2017. Gull Island. Newfoundland, Canada. |
| Breeding | Colony | Fixed-wing, electric (E384) and 4-copter, electric (DJI Phantom 4 Pro) | E384: 190 wingspan  Phantom 4 Pro: D35 | NA | Fixed-wing, vertical: 40, 75  Multi-rotor, vertical: 25 | ≥ 150 | Fixed-wing: 13 | No | No (during survey flight) | NA | NA | Fixed-wing: birds nearby flushed during take-off.  Multi-rotor: Response when drone made quick up-flight, causing propellor to increase speed and noise.  No other disturbances observed during flight. | Corregidor-Castro *et al.* 2022. Island of Langli, Wadden Sea. |
| Lesser Black-backed Gull *Larus fuscus* | Breeding | Colony | 4-copter, electric (DJI Inspire 1) | D57.9 | Horizontal & vertical | 10-40 | ≥ 50 | 3-4 | Yes  Recorded disturbance level (hop; flight; attack) before and during surveys using video camera. | Yes | NA | NA | Lowering drone from stationary point at 40 m directly above colony created immediate and widespread alarm; drone altitude always changed to the side of colony (20 m away) after this.  No disturbance ≥ 15m but marked increase below 15 m. No nests lost from predation. One short (5 second) attack of drone by a gull. Less disturbance than during walk-through survey, where all gulls took flight. | Rush *et al.* 2018. Skokholm Island, Wales. |
| Breeding | Colony | Fixed-wing, electric (E384) and 4-copter, electric (DJI Phantom 4 Pro) | E384: 190 wingspan  Phantom 4 Pro: D35 | NA | Fixed-wing, vertical: 40, 75  Multi-rotor, vertical: 25 | ≥ 150 | Fixed-wing: 13 | No | No (during survey flight) | NA | NA | Fixed-wing: birds nearby flushed during take-off.  Multi-rotor: Response when drone made quick up-flight, causing propellor to increase speed and noise.  No other disturbances observed during flight. | Corregidor-Castro *et al.* 2022. Island of Langli, Wadden Sea. |
| Yellow-footed Gull  *Larus livens* | Non-breeding | Individuals | 4-copter, electric (DJI Spark) | 143×143×55 | Vertically up and down | Vertical: 0-20 | NA | NA | Yes  Recorded if the gull showed agnostic behaviour when 1) rotors started, 2) drone took off in vertical flight until it reached 20 m high, and 3) drone stayed at 20 m for 2-min before landing. Agnostic behaviour was defined as; direct flight from a gull confronting the drone, around and over the device as close as 0.3m, and with intense vocalisation. | Yes | NA | NA | Gulls only showed agnostic behaviour (characterised as ‘mobbing’) when the drone was in ascendant movement once it took off. Individuals detected the drone from > 200 m away. Once vocalisations began, individuals flew to the drone. Adults always initiated mobbing, but once adults began, juveniles and sub-adults joined in, albeit less aggressively, Adults stopped mobbing if there were more than three adults in the group of gulls.  Mobbing was greater in areas further from the city of La Paz (i.e. less urban areas). Drone colour and sound did not influence reactions. | Frixione *et al.* 2021. La Paz and Baja California Sur, México. |
| Laughing Gull *Leucophaeus atricilla* | Breeding | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Strip transects | Vertical: 46, 61, 91, 122, 250 | 250 | 3-5 | Yes  Video recorded  vigilance, wing flapping, standing at or walking away from the nest, and escape behaviour (i.e., fight). For escape behaviour, tallied birds flying through camera frame as well as flushing from a nest. Responses were assigned weights of 1-4, and an overall disturbance score was calculated by summing weighted scores divided by total number of individuals during the sample period. Compared disturbance scores for different flight heights, five minutes pre-flight (control period) and five minutes post flight. | Yes | NA | NA | Significant increase in mean disturbance score across all treatments (five heights, pre- and post-flight) when compared to the grand mean, but no significant difference in the mean disturbance score for any specific treatment (i.e. survey height), when compared to the pre-flight control period. Significant increase in mean proportion of birds that showed an escape response across all treatments when compared to the grand mean, and in the mean proportion of birds that showed an escape response at 91 m when compared to the pre-flight control period. | Barr *et al.* 2020. East Flat Spoil, Gulf Coast, Texas, USA. |
| Franklin's Gull *Leucophaeus pipixcan* | Breeding | Colony | 8-copter, electric (DJI S1000+ airframe) | NA | Lawn-mower | Vertical: 45, 60, 120 | NA | 5, 7, 11 | No  Recorded total number of birds before, during, and after flight. Observations were made for up to 10 mins pre- and post-flight and up to 20 mins during flight. Effect of altitude was not considered due to small sample size. | Yes | NA | NA | No significant difference in number of birds off their nest before, during, and after flight. But when examining raw data, the mean number of birds was greater during flight than pre- or post-flight for the two Franklin’s gull colonies. | McKellar *et al.* 2021. BCR 11, Saskatchewan, Canada. |
| Black-billed Gull *Larus bulleri* | Breeding | Colony | 4-copter, electric (DJI Phantom 3) | NA | Transects | Vertical: 100 | NA | NA | No | No | NA | NA | No response observed. | Bell & Harborne 2019. Ashburton River/Hakatere River  Mouth, New Zealand. |
| Slender-billed Gull *Chroicocephalus genei* | Breeding | Colony | 4-copter, electric (DJI Phantom 4 Pro) | 38x22x32 | Parallel transects | Vertical: 20-50 | NA | 3-5 | No  Visual observer monitored behaviour before take-off and during flight. | No | NA | NA | Do not appeared to be disturbed. On rare occasions where behavioural response observed, flight altitude was increased. | Kellenberger *et al.* 2021. Sahelian Upwelling Marine Ecoregion, West African coast. |
| Breeding | Colony | 4-copter, electric (DJI Mavic Pro) | D33.5 | Lawn-mower  ‘Cautious overflight approach’ – drone flown in lawn-mower pattern at 30 m to assess nest attendance.  ‘Close-up approach’ – drone flown at 5 and 2 m altitude to detect clutches and eggs | Vertical: 2-70 | ≥ 150 | 1.5-3 | Yes  Recorded 1) duration of escape behaviour at visit 1 (laying) and 5 (hatching); 2) number of clutches/eggs predated due each visit. | Yes | NA | NA | Time spent away from nests was 1) lower for drone surveys at visit 1 (laying) and 5 (hatching) than for ground counts; 2) decreased across the breeding season.  At 30 m approach, no escape response across the breeding season. At 2-5m drone intrusion, all individuals flew away, but quickly returned to nests (within 10 ± 4sec, range = 5–22 sec).  No predation attempts observed during control ground and drone surveys. | Valle & Scarton 2021b.  Lagoon of Venice and Po Delta, Italy. |
| Mediterranean Gull *Larus melanocephalus* | Breeding | Colony | 4-copter, electric (DJI Mavic Pro) | D33.5 | Lawn-mower  ‘Cautious overflight approach’ – drone flown in lawn-mower pattern at 30 m to assess nest attendance.  ‘Close-up approach’ – drone flown at 5 and 2 m altitude to detect clutches and eggs | Vertical: 2-70 | ≥ 150 | 1.5-3 | Yes  Recorded 1) duration of escape behaviour at visit 1 (laying) and 5 (hatching); 2) number of clutches/eggs predated due each visit. | Yes | NA | NA | Time spent away from nests was 1) lower for drone surveys at visit 1 (laying) and 5 (hatching) than for ground counts; 2) decreased across the breeding season.  At 30 m approach, no escape response across the breeding season. At 2-5m drone intrusion, all individuals flew away, but quickly returned to nests (within 10 ± 4sec, range = 5–22 sec).  No predation attempts observed during control ground and drone surveys. | Valle & Scarton 2021b.  Lagoon of Venice and Po Delta, Italy. |
| Breeding | Colony | 4-copter, electric (DJI Mavic Pro) | D33.5 | Lawn-mower | Vertical: 20-70 | > 150 | NA | No | No | NA | NA | No eggs preyed upon, and no predation attempts observed. No response recorded. | Corregidor-Castro & Valle 2022. Po Delta, Italy. |
| Grey-headed Gull *Chroicocephalus cirrocephalus* | Breeding | Colony | 4-copter, electric (DJI Phantom 4 Pro) | 38x22x32 | Parallel transects | Vertical: 20-50 | NA | 3-5 | No  Visual observer monitored behaviour before take-off and during flight. | No | NA | NA | Do not appeared to be disturbed. On rare occasions where behavioural response observed, flight altitude was increased. | Kellenberger *et al.* 2021. Sahelian Upwelling Marine Ecoregion, West African coast. |
| Black-legged Kittiwake *Rissa tridactyla* | Breeding | Colony | 4-copter, electric (DAYA-550 Alien Carbon  Fiber Folding Quadcopter Frame Kit with 4 motors and 12-inch propellors) | Wheelbase: 55  Propellors: 30.5 | Started 50 m away from cliff face, then approached in a zigzag pattern until 20 m away. | Horizontal: < 20 to 50 | From base of cliff (i.e. on the ground) | < 5 | No  Initially approached a small colony at the margin of the cliff and recorded any behavioural responses. Taking images of the main colony only continued if they did not express any aggressive behaviour. | No | NA | NA | No noticeable movement of kittiwakes during flights; the number of kittiwakes circling remained relatively constant. A few individuals tried to chase away an aerial predator, the Glaucous Gull, but did not chase the drone. | Park 2020. Krykkjefjellet, Ossian Sarsfjellet, Irgensfjellet, Steinflåstupet, Kiærfjellet, Simlestupet, Svalbard Archipelago. |
| Breeding | Colony | 4-copter, electric (DJI Mavic 2 Enterprise Advanced) | D354 | Started on outcrop of land opposite and about halfway up the colony, 50 m horizontal distance away. Flew vertically up until 10 m above the top of the colony, then moved towards the colony until 30 m away. Moved in a zigzag pattern from top to bottom of the colony (i.e. lawn-mower pattern but in vertical plane) to survey. | Horizontal: 30 | 50 | < 3 | No | No | NA | NA | No noticeable movement of kittiwakes during flights; the number of kittiwakes circling remained constant. | T. Hart & A. Edney pers. comm. Fjortende Julibreen, northwestern Spitsbergen. |
| Breeding | Colony | 4-copter, electric (DJI Mavic 2 Enterprise Advanced) | D354 | Started at the base of the cliff, 50 m horizontal distance away. Flew vertically up until 10 m above top of colony, then moved towards the colony until 50 m away. Moved in a zigzag patten from top to bottom of the colony (i.e. lawnmower pattern but in vertical plane) to survey. | Horizontal: 50 | From a zodiac at the base of the cliff, 50 m away | < 3 | No | No | NA | NA | No noticeable movement of kittiwakes during flights; the number of kittiwakes circling remained constant. | T. Hart & A. Edney pers. comm. Alkefjellet, Lomfjordhalvøya, Spitsbergen, |
| Breeding | Colony | 4-copter, electric (DJI Mavic 2 Enterprise Advanced) | D354 | Started on the clifftop 30 m horizontal distance from the cliff edge. Flew vertically up until 10 m above the clifftop, then moved towards the colony until 30 m from the cliff face. Moved in a zigzag patten from top to bottom of the colony (i.e. lawnmower pattern but in vertical plane) to survey. | Horizontal: 30 | From the clifftop, 30 m away from the cliff edge | < 3 | No | No | NA | NA | No noticeable movement of kittiwakes during flights; the number of kittiwakes circling remained constant. | T. Hart & A. Edney pers. comm. Kapp Waldburg, Svalbard. |
| Breeding | Colony | 4-copter, electric (DJI Inspire 2 and DJI Mavic Air) | Large (Inspire 2): D60.5  Small (Mavic Air): D21.3 | NA | Close: 30 horizontal, 45 altitude  Far: 60 horizontal, 75 altitude | From a boat. Distance at drone launch not specified, but boat remained 122 – 889 m from colony during drone surveys. | Slow: 2  Fast: 8 | Yes  Video recorded 12-20 birds and made behavioural observations pre-flight (10 mins before take-off), during flight (range 3-15 mins), and post-flight (10 mins after landing. Response behaviours were recorded as: flushing, alert, alert head bobbing, and out of sight post-flush. | Yes | NA | NA | Four cases where > 10 attending birds flushed: once during survey flight, once just after take-off, and twice as the drone was returning to the boat. All birds returned with 60 seconds. Six cases of non-attending birds sat near the waterline flushing; most birds returned within 60 seconds.  In 6 out of 16 flights, there were significant differences in response behaviours, pre-, during, and post- flight, but only two of these were associated with predicted responses to drone operations:  1) During incubation, birds spent significantly more time ‘Out of Sight post-flush’ (OSP) during and post-flight compared to pre-flight for the slow, close, and small drone flight.  2) During chick-rearing, birds spend significantly more time OSP during flight compared to pre- and post-flight for the fast, close, and large drone flight. | Bishop *et al.* 2022. Beehive Islands, Gulf of Alaska. |
| Common Tern *Sterna hirundo* | Breeding | Colony | Fixed-wing, electric (AI-Multi UAS, Aerial Insight) | D210 | Horizontal passes/transects | Vertical: 91 & 122 | NA | NA | Yes.  Observer recorded disturbance level (0=none, 1=moderate, 2=high) for 10 flights and 10 control periods (10 minutes after each flight). | No | NA | NA | No statistical difference between drone flight and control period. Less disturbance than traditional in-colony counts. | Chabot *et al.* 2015. Tern Islands, New Brunswick, Canada. |
| Breeding | Colony | 2015: 6-copter, electric (Storm Drone 6 V3 GPS Flying Platform)  2016: 4-copter, electric (DJI Inspire 1 v2.0) | Storm Drone: 55x55x28  DJI Inspire 1: D57.9 | Horizontal passes/transects, except for one trial when then DJI was landed in the colony to assess maximum disturbance. | Storm Drone, Vertical: 15, 30  DJI Inspire 1, Vertical: 12 | 60  Except for one trial, when the DJI Inspire 1 was landed in the colony. | NA | Yes  2015: Drone flown over the colony three times, at 30 m altitude on outward flight and 15 m on return flight. Recorded number of birds flushed. Recorded maximum sound level of the Storm Drone at 15 and 30 m at the launch site, as the drone was flown toward the sound recorder, over it, past it, and back.  2016: Drone flown over the colony five times at 12 m altitude and landed in the colony once. | Yes | NA | Uncertain Sound of drone recorded, but effect on birds not reported. | 2015: All tern pairs (140/140) flushed during the first trial when the drone approached the colony at 30 m altitude but returned to their previous positions within 1 minute. The response decreased with each flight, until no terns flushed during the third trial.  2016: No large reaction, except when the drone was moving at high speeds or landed in the colony (27/30 terns flushed).  All birds appeared to return to their previous positions soon after flushing in both 2015 and 2016. | Reintsma *et al.* 2018. Poplar Island, Maryland, USA. |
| Sandwich Tern *Sterna sandvicensi* | Breeding | Colony | 4-copter, electric (DJI Mavic Pro) | D33.5 | Lawn-mower  ‘Cautious overflight approach’ – drone flown in lawn-mower pattern at 30 m to assess nest attendance.  ‘Close-up approach’ – drone flown at 5 and 2 m altitude to detect clutches and eggs | Vertical: 2-70 | ≥ 150 | 1.5-3 | Yes  Recorded 1) duration of escape behaviour at visit 1 (laying period) and 5 (hatching period); 2) number of clutches/eggs predated due each visit. | Yes | NA | NA | Time spent away from nests was 1) lower for drone surveys at visit 1 (laying) and 5 (hatching) than for ground counts; 2) decreased across the breeding season.  At 30 m approach, escape response at visit 1 (laying), but continued incubating their eggs in 2 out of 4 colonies at visit 5 (hatching). At 2-5m drone intrusion, all individuals flew away, but quickly returned to nests (within 10 ± 4sec, range = 5–22 sec).  No predation attempts observed during control ground and drone surveys. | Valle & Scarton 2021b. Lagoon of Venice and Po Delta, Italy. |
| Breeding | Colony | 4-copter, electric (DJI Mavic Pro) | D33.5 | Lawn-mower | Vertical: 2-70 | ≥ 150 | NA | Yes  Recorded 1) distance reached by crèches; 2) time spent by crèches far from the nesting site due to the drone | Yes | NA | NA | 1) Distance walked by crèches was significantly shorter for drone (5 ± 4 m) than ground (150 ± 20 m) surveys. Chicks remained indifferent or took brief (< 20 s) and short (< 5m) walks. Adults took brief (< 10 s) and low (< 5 m) flights. All birds rapidly returned to the roosting site and after a few seconds the drone hovering at 2 m was barely noticed.  2) Time spent away from the breeding site was significantly shorter for drone ( 5 ± 5 s) than ground (636 ± 258 s) surveys.  No chicks were predated during surveys. | Valle & Scarton 2021a. Lagoon of Venice, Italty. |
| Common Tern *Sterna hirundo*, Arctic Tern *S. paradisaea* & Sandwich Tern *S. sandvicensi* | Foraging | Feeding flock | 4-copter, electric (DJI Mavic Pro) | D33.5 | Transects &  hovering | Vertical: 120 | NA | 200 | No | No | NA | NA | None recorded. | Lieber *et al.* 2019. The Narrows, Northern Ireland, UK. |
| Common Tern *Sterna hirundo*, Arctic Tern *S. paradisaea* & Sandwich Tern *S. sandvicensi* | Foraging | Feeding flock | 4-copter, electric (DJI Phantom 3) | D35 | Transects & hovering | Vertical: 100 | NA | 200 | No | No | NA | NA | None recorded. | Lieber *et al.* 2021. The Narrows, Northern Ireland, UK. |
| Terns *Sternidae* | Foraging | Feeding flock/individuals | 4-copter, electric, (DJI Mavic Pro and DJI Phantom 3 Advanced) | Mavic Pro: D33.5  Phantom 3 Advanced: D35 | Transects | DJI Mavic Pro, vertical: 74  DJI Phantom 3 Advanced, vertical: 61 | ~ 100 | NA | No | No | NA | NA | No response (e.g. evasive flying/diving behaviours away from the drone, alarm calling) observed. | Costagliola-Ray *et al.* 2022. Strangford Lough, Northern Ireland. |
| NA | Individuals/groups | 4-copter, electric (DJI Mavic 2 Zoom) | D35.4 | NA | Vertical: 30, 50, 75, 100 | NA | ~11 at 50 m | No  Evaluated possible interference in behaviour at 50 m flight height in videos with identified marine megafauna species. | Yes | NA | NA | A flock of Sternidae took flight collectively when the drone approached. | Barreto *et al.* 2021. Doce River’s region Espírito Santo, Brazil. |
| Crested Tern *Thalasseus bergii* | Breeding | Colony | 8-copter, electric (X8 3D Robotics) | 61x61x20.3 | Lawn-mower | Vertical: 75 | 100 | 2-3 | No  Observers looked for group startle response, as bird taking flight would affect colony counts. | No | NA | NA | No group startle response observed at 75 m. | Hodgson *et al.* 2016. Two tropical islands at Ashmore Reef Commonwealth Marine Reserve, and Adele Island, Australia. |
| Gull-billed Tern *Gelochelidon nilotica* | Breeding | Colony | 4-copter, electric (DJI Mavic Pro) | D33.5 | Lawn-mower | Vertical: 3-70 | 150 | 0.42 | No  Disturbance estimated from: 1) mean duration of permanence of  drone over colony; 2) time spent away from nests  by incubating birds, until the last breeding bird returned;  3) distance walked/swum by chicks. | Yes | NA | NA | Some response. No nest desertions or clutch/chick predations; short time spent far from nests alarming (105 ± 67 s); very short distance walked/swum by chicks (0.6 ± 0.8 m). | Scarton & Valle 2021. Lagoon of Venice and Po Delta, Italy. |
| Breeding | Colony | 4-copter, electric (DJI Mavic Pro) | D33.5 | Lawn-mower  ‘Cautious overflight approach’ – drone flown in lawn-mower pattern at 30 m to assess nest attendance.  ‘Close-up approach’ – drone flown at 5 and 2 m altitude to detect clutches and eggs | Vertical: 2-70 | ≥ 150 | 1.5-3 | Yes  Recorded 1) duration of escape behaviour at visit 1 (laying period) and 5 (hatching period); 2) number of clutches/eggs predated due each visit. | Yes | NA | NA | Time spent away from nests was 1) lower for drone surveys at visit 1 (laying) and 5 (hatching) than for ground counts; 2) decreased across the breeding season.  At 30 m approach, escape response at visit 1 (laying), but continued incubating their eggs in 2 out of 4 colonies at visit 5 (hatching). At 2-5m drone intrusion, all individuals flew away, but quickly returned to nests (within 10 ± 4sec, range = 5–22 sec).  No predation attempts observed during control ground and drone surveys. | Valle & Scarton 2021b. Lagoon of Venice and Po Delta, Italy |
| Caspian Tern *Hydroprogne caspia* | Breeding | Colony | 4-copter, electric (DJI Phantom 4 Pro) | 38x22x32 | Parallel transects | Vertical: 20-50 | NA | 3-5 | No  Visual observer monitored behaviour before take-off and during flight. | No | NA | NA | Do not appeared to be disturbed. On rare occasions where behavioural response observed, flight altitude was increased. | Kellenberger *et al.* 2021. Sahelian Upwelling Marine Ecoregion, West African coast. |
| Aleutian Tern Onychoprion *aleutic* | Breeding | Colony | 4-copter, electric (3DR Solo) | ‎45.7x45.7x25.4 | NA | Vertical: 15-61 | > 100 | NA | No  Observer recorded number of aerial terns and nest attendance during and without drone flights. | No | NA | NA | No negative effect on nest attendance or number of aerial birds. No mobbing of drone. | Magness *et al.* 2019. Kenai National Wildlife Refuge, Alaska. |
| Least Tern Sternula *antillarum* | Breeding | Colony | Fixed-wing, electric (senseFly eBee Plus)  Modifications were made to make the drone appear less like a predator: irregular lines (dazzle camouflage) to break up the shape and solid sky-blue camouflage on the underside. | 96 wingspan | Horizontal passes | Vertical: 85, 116, 119 | 350 | NA | Yes  Recorded number of birds that responded to the drone. If more than 10% of the birds flushed the drone returned to launch location and flight parameters were reassessed before the next launch. Following a flight with observed disturbance, the drone was not launched again on the same day. | Yes | NA | NA | Disturbance appeared to depend on drone visibility in the sky, determined by drone camouflage and % cloud cover. Substantial flushing occurred when the drone had no camouflage (black colour) and there was 100% cloud cover, and when the drone had dazzle camouflage (irregular lines and colouration across the underside of the drone) and 50% cloud cover. No flushing occurred when the drone was a solid sky blue colour and there was 0% cloud cover. | Mapes *et al.* 2020. Lea-Hutaff Island, North Carolina, USA. |
| Black Tern *Chlidonias niger* | Breeding | Colony | 8-copter, electric (DJI S1000+ airframe) | D104.5 | Lawn-mower | Vertical: 45, 60, 120 | NA | 5, 7, 11 | No  Recorded total number of birds before, during, and after flight. Observations were made for up to 10 mins pre- and post-flight and up to 20 mins during flight. Effect of altitude was not considered due to small sample size. | Yes | NA | NA | No significant difference in number of birds off their nest before, during, and after flight. But when examining raw data, the mean number of birds was greater during flight than pre- or post-flight for one out of two Black Tern colonies. | McKellar *et al.* 2021. BCR 11, Saskatchewan, Canada. |
| White-fronted Tern *Sterna striata* | Breeding | Colony | 4-copter, electric (DJI Phantom 3) | NA | Transects | Vertical: 100 | NA | NA | No | No | NA | NA | No response observed. | Bell & Harborne 2019. Ashburton River/Hakatere River  Mouth, New Zealand. |
| Royal Tern *Thalasseus maximus* | Breeding | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Strip transects | Vertical: 46, 61, 91, 122, 250 | 250 | 3-5 | Yes  Video recorded vigilance, wing flapping, standing at or walking away from the nest, and escape behaviour (i.e. flight). For escape behaviour we tallied birds flying through camera  frame as well as flushing from a nest. Responses were assigned weights of 1-4, and an overall disturbance score was calculated by summing the weighted scores divided by the total number of individuals during the sample period. Compared disturbance scores for different flight heights, five minutes pre-flight (control period) and five minutes post flight | Yes | NA | NA | Significant increase in mean disturbance score across all treatments (five heights, pre- and post-flight) when compared to the grand mean. No significant difference in mean proportion of birds that showed an escape response across all treatments when compared to the grand mean, or specific treatments (i.e. survey heights) when compared to the pre-flight control period. | Barr *et al.* 2020. East Flat Spoil, Gulf Coast, Texas, USA. |
| Breeding | Colony | 4-copter, electric (DJI Phantom 4 Pro) | 38x22x32 | Parallel transects | Vertical: 20-50 | NA | 3-5 | No  Visual observer monitored behaviour before take-off and during flight. | No | NA | NA | Do not appeared to be disturbed. On rare occasions where behavioural response observed, flight altitude was increased. | Kellenberger *et al.* 2021. Sahelian Upwelling Marine Ecoregion, West African coast. |
| Black Skimmer *Rynchops niger* | Breeding | Colony | 4-copter, electric (DJI Phantom 3) | D35 | Strip transects | Vertical: 46, 61, 91, 122, 250 | 250 | 3-5 | Yes  Video recorded vigilance, wing flapping, standing at or walking away from the nest, and escape behaviour (i.e., fight). For escape behaviour we tallied birds flying through camera  frame as well as flushing from a nest. Responses were assigned weights of 1-4, and an overall disturbance score was calculated by summing the weighted scores divided by the total number of individuals during the sample period. Compared disturbance scores for different flight heights, five minutes pre-flight (control period) and five minutes post flight | Yes | NA | NA | No significant difference in:  1) Mean disturbance score across all treatments (five heights, pre- and post-flight) when compared to the grand mean, or specific treatments (i.e. survey heights) when compared to the pre-flight control period.  2) Mean proportion of birds that showed an escape response across all treatments when compared to the grand mean, or specific treatments when compared to the pre-flight control period. | Barr *et al.* 2020. East Flat Spoil, Gulf Coast, Texas, USA. |
| Alcidae | | | | | | | | | | | | | | |
| Thick-billed Murre *Uria lomvia* | Breeding | Colony | 4-copter, electric (DJI Phantom 4) | D35 | 1) Horizontally towards cliff-face  2) From above (drone lowered from cliff-edge above colony)  3) Approached from below (drone raised from point beneath colony)  Note, drone always took off from edge of cliff, (either 15-20 m directly above plot or 30 m further along cliff edge), and was then flown to condition 1), 2) or 3). | Horizontal: 15-30 | 1) Edge of cliff 15-20 m directly above plot from plot  2) 30 m further along cliff-edge | NA | Yes  Calculated ratio of birds flushing (number flushed / total number of birds) from video recorded by observer. Repeated flights over a small period (hours) and long period (days) to assess habituation. | Yes | NA | NA | Minimal response (8.5% of murres flushed, but >99% of these were non-breeders). No impact on breeding success except at site where aerial predators were abundant, and several birds lost eggs to predators. | Brisson‐Curadeau *et al.* 2017. Coats Island and Digges Island, Canada, |
| Thick-billed Murre *Uria lomvia* | Non-breeding | Colony | 4-copter, electric (DJI Phantom 4) | D35 | 1) Horizontally towards cliff-face  2) From above (drone lowered from cliff-edge above colony)  3) Approached from below (drone raised from point beneath colony)  Note, drone always took off from edge of cliff, (either 15-20 m directly above plot or 30 m further along cliff edge), and was then flown to condition 1), 2) or 3). | Horizontal: 15-30 | 1)Edge of cliff 15-20 m directly above plot from plot 2)30 m further along cliff-edge | NA | Yes  Calculated ratio of birds flushing (number flushed / total number of birds) from video recorded by observer. Repeated flights over a small period (hours) and long period (days) to assess habituation. | Yes | NA | NA | Clear response (8.5% of murres flushed, most of which were non-breeders). Little evidence for habituation – flushing intensity constant across consecutive days. | Brisson‐Curadeau *et al.* 2017. Coats Island and Digges Island, Canada, |
| Common Guillemot/Murre *Uria aalge* | Breeding | Colony | 4-copter, electric (Spyder X8, SkyHero) | NA | Horizontal passes/transects along cliff-face | Horizontal: 25-80 | NA | 5 | Yes  Counted number of birds flushing from video recorded by observer. | Yes | NA | NA | 2015: Some response at 80 m (18% flushed), but comparable to at 20 m (22% flushed); and no birds with eggs left colony.  2016: Clear response by non-breeders (93% flushed). 10% of active breeding sites lost due to egg displacement and egg predation by herring gulls. | Brisson‐Curadeau *et al.* 2017. Gull Island. Newfoundland, Canada. |
| Breeding | Colony | 4-copter, electric (DJI Inspire 2 and DJI Mavic Air) | Large (Inspire 2): D60.5  Small (Mavic Air): D21.3 |  | Close: 30 horizontal, 45 altitude  Far: 60 horizontal, 75 altitude | From a boat. Distance at drone launch not specified, but boat remained 122 – 889 m from colony during drone surveys. | Slow: 2  Fast: 8 | Yes  Video recorded 12-20 birds and made behavioural observations pre-flight (10 mins before take-off), during flight (range 3-15 mins), and post-flight (10 mins after landing. Response behaviours were recorded as: flushing, alert, alert head bobbing, and out of sight post-flush. | No | NA | NA | No flushes observed. No significant differences in response behaviours during flight, compared to pre- or post-flight; only one significant different between pre- and post-flight. | Bishop *et al.* 2022. Beehive Islands, Gulf of Alaska. |
| Foraging | Individuals/groups | 4-copter, electric (DJI Phantom 4 Advanced) | D35 | Flew 100 m ahead of the vessel, which circumnavigated the Island of Stroma. | Vertical: 70 | NA | NA | No  Vessel-based observers recorded potential disturbance behaviour: vigilance, diving, flight responses. | No | NA | NA | No response observed. | Slingsby *et al.* 2022. Island of Stroma, Scotland. |
| Anatidae | | | | | | | | | | | | | | |
| Common Eider *Somateria mollissima* | Breeding | Colony | Fixed-wing, electric (Trimble UX5) | 100 wingspan | Lawn-mower | Vertical: 75, 100, 120 | NA | NA | No  Collected daily nest attendance behaviour on day of drone survey (drone day) and a paired control day before the surveys (control day) using trail and surveillance cameras. Recorded number and duration of recess events (where female eider was off her nest). Classified behaviour 30 minutes pre-flight, during, 1 hour post-flight, into six categories: resting, nest maintenance, low scan, high scan, overhead vigilance, and off-nest. | Yes | NA | NA | - No changes in nest attendance patterns on days with drone flights compared to the day prior without drone flight.  -Timing of recess events did not correspond to drone flight times. (Only observed one recess event by a single eider during the drone operations.)  - No effect of drone flights on recess duration; however, recess durations were longer with increased number of exposures to the drone.  - No overhead vigilance recorded during drone flights.  - Decreased nest maintenance activity and increased resting during drone flight compared to pre- and post-flight.  - Increased vigilance (both low and high scan) during post-flight periods and resumed pre-flight nest maintenance behaviours. | Ellis-Felege *et al.* 2021. Wapusk National Park, Manitoba, Canada |
| Breeding | Colony | 4-copter, electric (DJI Phantom 4 Pro) | D35 | Lawn-mower | Vertical: 30 | ~ 12 m from nearest eider nest | 10 | Yes  Compared heart rates of incubating eiders pre-flight (control) and during flight, when the drone was flown at 0-150 m, 151-300 m and > 300 m lateral distance from the nest. | No | No | NA | No focal eiders flushed during drone flights and no focal nests were predated. No significant difference in heart-rate response:  1) Across all categories (pre-flight control, 0-150 m, 151-300 m, > 300m lateral distance from nest)  2) Due to date of incubation | Geldart *et al.* 2022. East Bay Island (Mitivik), Nunavut, Canada. |

**Table A5.** Raw data for Figure 1, which is a violin plot of height above breeding ground-nesting seabirds at which a multi-rotor drone induced no (n=38), low (n=28) or high (n=9) adverse behavioural responses. These data are gathered from studies in Table S4 that used a multi-rotor drone to monitor breeding, ground-nesting seabirds and provided appropriate information on disturbance category and height (e.g. if disturbance could not be assigned to a single category the study could not be used). Disturbance categories are defined as: none = no behavioural response; low = a minor adverse behavioural response (e.g. vigilance); high = a marked increase in adverse behavioural response (e.g. escape). For studies where a range of heights were measured, height is the lower bound for disturbance category ‘none’ and the upper bound for disturbance categories ‘low’ and ‘high’. For example, no disturbance (category ‘none’) at 20-30 m height in the original study, meant 20 m height used in Figure 1, because there was no disturbance as low as 20 m above breeding seabirds. Conversely, ‘low’ or ‘high’ disturbance at 20-30 m height in the original study, meant 30 m height used in Figure 1, because as high as 30 m there was still low- or high-level disturbance. Figure 1 therefore provides the minimum height at which no disturbance may be observed and the maximum height at which low and high disturbance may be observed, which are important parameters when trying to maximise image resolution but minimise disturbance.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Study** | **Species** | **Disturbance category** | **Height given in original study / m** | **Height used in Figure 1 / m** | **Note** |
| Mustafa et al. 2017 | Gentoo Penguin *Pygoscelis papua* | low | 20 to 50 | 50 |  |
| Mustafa et al. 2017 | Gentoo Penguin *Pygoscelis papua* | high | 15 to 20 | 20 |  |
| Goebel et al. 2015 | Gentoo Penguin *Pygoscelis papua* | none | 30 to 60 | 30 |  |
| Rümmler et al. 2018 | Gentoo Penguin *Pygoscelis papua* | low | < 30 | 30 |  |
| Rümmler et al. 2018 | Gentoo Penguin *Pygoscelis papua* | high | 20 | 20 |  |
| Dunn et al*.* 2021 | Gentoo Penguin *Pygoscelis papua* | low | 35 | 35 |  |
| Ratcliffe et al. 2015 | Gentoo Penguin *Pygoscelis papua* | none/low | 30 | 30 |  |
| Crofts & Stanworth 2020 | Gentoo Penguin *Pygoscelis papua* | none | ≥ 15 | 15 |  |
| Wethington et al. 2023 | Gentoo Penguin *Pygoscelis papua* | none | ≥ 30 | 30 |  |
| Mustafa et al. 2017 | Adélie Penguin *Pygoscelis adeliae* | low | 50 | 50 |  |
| Mustafa et al. 2017 | Adélie Penguin *Pygoscelis adeliae* | high | 15 to 20 | 20 |  |
| Rümmler et al. 2018 | Adélie Penguin *Pygoscelis adeliae* | low | < 50 | 50 |  |
| Rümmler et al. 2018 | Adélie Penguin *Pygoscelis adeliae* | high | 10 to 15 | 15 |  |
| Rümmler et al. 2016 | Adélie Penguin *Pygoscelis adeliae* | low | 20 to 50 | 50 |  |
| Rümmler et al. 2016 | Adélie Penguin *Pygoscelis adeliae* | high | below 20 | 20 |  |
| Wethington et al. 2023 | Adélie Penguin *Pygoscelis adeliae* | none | ≥ 30 | 30 |  |
| Dickens et al. 2021 | Adélie Penguin *Pygoscelis adeliae* | low | 50 to 60 | 60 |  |
| Dunn *et al.* 2021 | Chinstrap Penguin *Pygoscelis antarctica* | low | 35 | 35 |  |
| Goebel et al. 2015 | Chinstrap Penguin *Pygoscelis antarctica* | none | 30 to 60 | 30 |  |
| Krause et al. 2021 | Chinstrap Penguin *Pygoscelis antarctica* | none | 30 | 30 |  |
| Liu et al. 2020 | Chinstrap Penguin *Pygoscelis antarctica* | none | 25 to 40 | 25 |  |
| Dickens et al. 2021 | Chinstrap Penguin *Pygoscelis antarctica* | low | 50 to 60 | 60 |  |
| Weimerskirch et al. 2018 | King Penguin *Aptenodytes patagonicus* | low | 25 | 25 |  |
| Dickens et al. 2021 | King Penguin *Aptenodytes patagonicus* | low | 50 to 100 | 100 |  |
| Weimerskirch et al. 2018 | Macaroni penguin *Eudyptes chrysolophus* | low | 25 | 25 |  |
| Dickens et al. 2021 | Macaroni penguin *Eudyptes chrysolophus* | low | 50 to 100 | 100 |  |
| Weimerskirch et al. 2018 | Southern rock-hopper penguin *Eudyptes chrysocome* | low | 25 | 25 |  |
| Crofts & Stanworth 2020 | Southern rock-hopper penguin *Eudyptes chrysocome* | none | ≥ 15 | 15 |  |
| Mattern et al. 2021 | Erect-crested Penguin *Eudyptes sclateri* | none | 40 to 80 | 40 |  |
| Rexer-Hueber & Parker 2020 | Erect-crested Penguin *Eudyptes sclateri* | none | 40 to 80 | 40 |  |
| Rümmler et al. 2021a | Emperor Penguin *Aptenodytes forsteri* | low | 20 | 20 |  |
| Rümmler et al. 2021b | Emperor Penguin *Aptenodytes forsteri* | none | > 70 | 70 |  |
| Muller et al. 2019 | Yellow-eyed Penguin *Megadyptes antipodes* | low | 30 to 50 | 50 |  |
| Weimerskirch et al. 2018 | Southern giant petrel *Macronectes giganteus* | low | 50 | 50 |  |
| Crofts & Stanworth 2020 | Southern giant petrel *Macronectes giganteus* | none | ≥ 15 | 15 |  |
| Fudala & Bialik 2022 | Southern giant petrel *Macronectes giganteus* | none | 50 to 130 | 50 |  |
| Fudala & Bialik 2022 | Southern giant petrel *Macronectes giganteus* | low | 30 | 30 |  |
| Dickens et al. 2021 | Wandering albatross *Diomedea exulans* | low | 120 | 120 |  |
| Weimerskirch et al. 2018 | Sooty albatross *Phoebetria fusca* | low | 25 | 25 |  |
| Weimerskirch et al. 2018 | Light-mantled sooty albatross *Phoebetria palpebrata* | low | 25 | 25 |  |
| McClelland et al. 2016 | Tristan Albatross *Diomedea dabbenena* | none | 20 to 150 | 20 |  |
| Rexer-Huber et al. 2020 | Campbell Albatross *Thalassarche impavida* | none | ≥ 150 | 150 |  |
| Rexer-Huber et al. 2020 | Grey-headed Albatross *Thalassarche chrysostoma* | none | ≥ 150 | 150 |  |
| Crofts & Stanworth 2020 | Black-browed Albatross *Thalassarche melanophris* | none | ≥ 15 | 15 |  |
| Rexer-Hueber & Parker 2020 | Salvin’s Albatross *Thalassarche salvini* | none | 40 to 80 | 40 |  |
| Parker et al. 2022 | White-capped albatross *Thalassarche cauta steadi* | none | 30 | 30 |  |
| Weimerskirch et al. 2018 | Imperial cormorant *Leucocarbo atriceps* | low | 50 | 50 |  |
| Yorio et al. 2020 | Imperial cormorant *Leucocarbo atriceps* | none | 20 to 80 | 20 |  |
| Irigoin-Lovera et al. 2019 | Guanay cormorant *Phalacrocorax bougainvilli* | none | > 50 | 50 |  |
| Irigoin-Lovera et al. 2019 | Guanay cormorant *Phalacrocorax bougainvilli* | high | 5 to 10 | 10 |  |
| Francis et al. 2022 | Reed Cormorant *Microcarbo africanus* & White-breasted Cormorant *Phalocrocorax lucidus* | low | > 16 | 16 |  |
| Oosthuizen et al. 2020 | Antarctic shag *Leucocarbo bransfieldensis* | none | 90 | 90 |  |
| Dunn et al. 2021 | South Georgia shag *Leucocarbo atriceps georgianus* | low | 50 | 50 |  |
| T. Hart & A. Edney pers.comm | European shag *Gulosus aristotelis* | none | 60 to 70 | 60 |  |
| Irigoin-Lovera et al. 2019 | Peruvian Booby *Sula variegata* | none | > 50 | 50 |  |
| Irigoin-Lovera et al. 2019 | Peruvian Booby *Sula variegata* | high | 5 to 10 | 10 |  |
| Espíndola et al. 2023 | Red-footed Booby *Sula sula* | none | 30 | 30 |  |
| I. Juárez- Martinez pers. comm. | Northern Gannet *Morus bassanus* | none | 50 to 100 | 50 |  |
| Irigoin-Lovera et al. 2019 | Peruvian Pelican *Pelecanus thagus* | none | > 50 | 50 |  |
| Irigoin-Lovera et al. 2019 | Peruvian Pelican *Pelecanus thagus* | high | 5 to 10 | 10 |  |
| Hodgson *et al.* 2016 | Lesser Frigatebird *Fregata ariel* | none/low | 75 | 75 |  |
| Villegas et al. 2018 | Magnificent Frigatebird *Fregata magnificens* | none | 80 | 80 |  |
| Weimerskirch et al. 2018 | Brown/South polar skua *Catharacta antarctica/C. maccormicki* | low | 50 | 50 |  |
| Choi et al. 2020 | Saunder’s Gull *Saundersilarus saundersi* | none | 30 | 30 |  |
| Scarton & Valle 2022 | Black-headed Gull *Chroicocephalus ridibundus* | none/low | 30 | 30 |  |
| Grenzdörffer 2013 | Common Gull *Larus canus* | none/low | ≥ 15 | 15 |  |
| Blight et al. 2019 | Glaucous-winged gull *Larus glaucescens* | none | 76 to 90 | 76 |  |
| Albores-Barajas et al. 2018 | Western Gull *Larus occidentalis* | none | 60 | 60 |  |
| Albores-Barajas et al. 2018 | Western Gull *Larus occidentalis* | low | ≥ 50 | 50 |  |
| Corregidor-Castro et al. 2022 | Herring Gull *Larus argentatus* | none | 25 | 25 |  |
| Rush et al. 2018 | Lesser Black-backed *Gull Larus fuscus* | none | ≥ 15 | 15 |  |
| Rush et al. 2018 | Lesser Black-backed *Gull Larus fuscus* | high | < 15 | 15 |  |
| Corregidor-Castro et al. 2022 | Lesser Black-backed *Gull Larus fuscus* | none | 25 | 25 |  |
| Barr et al. 2020 | Laughing Gull *Leucophaeus atricilla* | NA | NA | NA | Difficult to interpret effect of specific altitudes |
| McKellar et al. 2021 | Franklin's Gull *Leucophaeus pipixcan* | NA | NA | NA | Effect of altitude not considered as sample size too small |
| Bell & Harborne 2019 | Black-billed Gull *Larus bulleri* | none | 100 | 100 |  |
| Kellenberger *et al.* 2021 | Slender-billed Gull *Chroicocephalus genei* | none/low | 20 to 50 | NA |  |
| Valle & Scarton 2021b | Slender-billed Gull *Chroicocephalus genei* | none/low | 30 | 30 |  |
| Valle & Scarton 2021b | Mediterranean Gull *Larus melanocephalus* | none/low | 30 | 30 |  |
| Corregidor-Castro & Valle 2022 | Mediterranean Gull *Larus melanocephalus* | none | 20 to 70 | 20 |  |
| Kellenberger *et al.* 2021 | Grey-headed Gull *Chroicocephalus cirrocephalus* | none/low | 20 to 50 | NA |  |
| Reintsma et al. 2018 | Common Tern *Sterna hirundo* | high | 30 | 30 |  |
| Reintsma et al. 2018 | Common Tern *Sterna hirundo* | low | 12 | 12 |  |
| Valle & Scarton 2021b | Sandwich Tern *Sterna sandvicensi* | high, but lower than ground surveys | 30 | NA | Considered duration of escape behaviour as a measure of disturbance level, but most studies categorised any form of escape behaviour as high disturbance |
| Valle & Scarton 2021a | Sandwich Tern *Sterna sandvicensi* | high, but lower than ground surveys | 2 to 70 | NA | Difficult to interpret effect of specific altitudes |
| Hodgson *et al.* 2016 | Crested Tern *Thalasseus bergii* | none/low | 75 | 75 |  |
| Scarton & Valle 2021 | Gull-billed Tern Gelochelidon nilotica | low/high | 3 to 70 | NA |  |
| Valle & Scarton 2021b | Gull-billed Tern *Gelochelidon nilotica* | high, but lower than ground surveys | 30 | NA | Considered duration of escape behaviour as a measure of disturbance level, but most studies categorised any form of escape behaviour as high disturbance |
| Kellenberger *et al.* 2021 | Caspian Tern *Hydroprogne caspia* | none/low | 20 to 50 | NA |  |
| Magness *et al.* 2019 | Aleutian Tern *Onychoprion aleutic* | none/low | 15 to 61 | NA |  |
| McKellar et al. 2021 | Black Tern *Chlidonias niger* | NA | NA | NA | Effect of altitude not considered as sample size too small |
| Bell & Harborne 2019 | White-fronted Tern *Sterna striata* | none | 100 | 100 |  |
| Barr et al. 2020 | Royal Tern *Thalasseus maximus* | NA | NA | NA | Difficult to interpret effect of specific altitudes |
| Kellenberger *et al.* 2021 | Royal Tern *Thalasseus maximus* | none/low | 20 to 50 | NA |  |
| Ellis-Felege *et al.* 2021 | Common Eider *Somateria mollissima* | none | 70 to 120 | 75 |  |
| Geldart et al. 2022 | Common Eider *Somateria mollissima* | none/low | 30 | 30 |  |

**Pre-deployment Checks**

**Table A6.** Example pre-deployment checklist for flying a multi-rotor drone, which should help ensure both drone and pilot are fit to fly in the local operating conditions on the day.

|  |  |  |
| --- | --- | --- |
| **Planned survey date:** |  | |
| **Survey objectives:** |  | |
| **Checklist:** | **Notes** | **Completed?** |
| 1. **Equipment and set-up** | | |
| Recommended equipment list | * Drone x1 * Batteries x3 (1 for use, 2 spare) * SD cards x2 (1 for use, 1 spare) * Controllers x2 (1 for use, 1 spare) * Landing platform x1 * Detox wipes (to clean the drone in between sites to minimise biosecurity risk) * Spare propellors * Spare motors * Safety glasses x2 (1 for pilot, 1 for visual observer) * Gloves x1 pair (if the drone will be hand-caught) * Handheld anemometer x1 (to determine wind speed on site) * Fire extinguisher/fire blanket and lipo-safe bags (in case of battery failure) |  |
| Set-up | * Built-in software is up to date * Batteries fully charged and inserted in drone * SD card empty and inserted in drone * Payloads securely attached * Remote controller has an empty cache |  |
| 1. **Operating conditions** | | |
| Weather | Weather conditions must not impede pilot vision, ability to control the drone or drone function. Avoid flying if:   * Maximum wind speed > 35 km/h (22 mph, 10 m/s) for multi-rotors * Heavy precipitation * Fog |  |
| Hazards | Check for:   * Flight restrictions in the survey area, using a tool like SkyDemon * Other hazards, especially mobile objects that may not have been present during the pre-site assessment e.g. people, animals, vehicles |  |
| 1. **Personnel** | | |
| Are pilot and visual observer fit to perform their duties? | Check against the IMSAFE mnemonic:   * Illness – are they suffering from any illness? * Medication – are they currently taking any drugs? * Stress - are they overly worried about other factors in their life? * Alcohol – have they consumed any alcohol within the last 8 to 24 hours? * Fatigue – have they had sufficient sleep? * Eating – have they had sufficient hydration, sustenance and correct nutrition? To avoid situations of extreme fatigue, it is recommended that flight operations team members do not operate more than 10 hours in any 24-hour period. |  |
| 1. **Drone settings** | | |
|  | * Compass and IMU calibrated. * GPS signal present (check this away from metal objects or other sources of interferences). * Drone home point set as controller, not take-off location. * ‘Return to home’ failsafe appropriately set e.g., fly vertically up then horizontal, rather than shortest possible route (a diagonal line). * Camera set to take images at certain time intervals (recommended for manual flights, so the pilot only needs to fly at constant speed and not have to take photographs as well). * Image capture set to RAW to provide the maximum information possible, unless battery capacity is likely to be an issue and then image capture can be set to JPEG. |  |
| 1. **Flying** | | |
| Take-off | 1. *Select take-off and landing position (TOLP)*  * From land: TOLP should be as even as possible, far from rock/ice walls that could impede GPS reception or create establishing air currents on the way up/down. * From boat: TOLP should have as much free space as possible, and for moving vessels is often best located at the stern. * Area downwind of the drone should be clear, as GPS compensation is only effective when it is a few feet above ground, making the drone initially vulnerable to drift from wind gusts. * At least 50 m from the study area to minimise wildlife disturbance.  1. *Position drone*  * From land: Position drone on ground, so it is facing away from pilot (i.e., camera facing away) to ensure the drone moves in the expected direction (e.g. moving the control to the right will move the drone to the right) when it is first airborne. * From boat: Often easier from the observer’s hand, rather than the floor of the vessel. Hold drone at arm’s length and facing away from the vessel, with the pilot standing behind, so the vessel will move away from the drone as it becomes airborne, and the controls are as intuitive as possible. * Gimbal is not touching ground/observer’s hand, and its movements are not impeded when drone is turned on. Otherwise, might end up with a tilted camera view throughout the flight.  1. *Take-off*  * From land: Give a voice warning, such as ‘Take-off’, when the drone is about to take-off, so those nearby are aware, including the visual observer. * From boat: Pilot should instruct ‘keep hold’, then rev the engines, just before saying ‘let go’. |  |
| During flight | * Lawn-mower (grid) flight pattern (in the horizontal plane for ground-nesting seabirds, or vertical plane for cliff-nesting seabirds) is typically advised for counts, with 70-80% forward/backward overlap and 60% sideways overlap to ensure that no part of the colony is missed. * Change altitude and speed at least 50 m away from the colony to minimise disturbance. |  |
| Landing | * Return drone for landing when battery levels reach 30%. * Land at least 50 m from the study area to minimise wildlife disturbance. * From boat: * Often easier if observer hand catches the drone. The safest place to catch the drone is from one of the stern quarters, as there will be less movement here and if the boat is moving, it will naturally be moving away from the drone if anything goes wrong, giving the pilot more options. * If the boat is moving, slowly bring the drone in to several meters away and practice matching the speed of the boat with the drone alongside the boat, near the stern. Keep the drone facing forwards, keeping pace with the boat, and slowly come sideways, closing the distance until the catcher can grab it without leaning out. The catcher needs to hold the drone the second it hits the surface (i.e. hand), otherwise it will try to react and compensate for the change in movement, as the boat is moving without the drone trying to. * As soon as the catcher has hold of the drone, either flip it upside down to turn it off (this is the emergency cut off), or the pilot must power down. If turning upside down, will likely need IMU re-calibrating more often. |  |

**REFERENCES**

ALBORES-BARAJAS, Y.V., SOLDATINI, C., RAMOS-RODRÍGUEZ, A., ALCALA-SANTOYO, J.E., CARMONA, R. & DELL’OMO, G. 2018. A new use of technology to solve an old problem: Estimating the population size of a burrow nesting seabird *PLoS ONE* 13: e0202094. doi: 10.1371/journal.pone.0202094

AZIZEH, T., SPROGIS, K., SOLEY, R., NIELSEN, M., UHART, M., SIRONI, M., MARÓN, C., BEJDER, L., MADSEN, P. & CHRISTIANSEN, F. 2021. Acute and chronic behavioral effects of kelp gull micropredation on southern right whale mother-calf pairs off Península Valdés, Argentina. *Marine Ecology Progress Series* 668: 133-148. doi: 10.3354/meps13716

BARNAS, A. F., GELDART, E. A., LOVE, O. P., JAGIELSKI, P. M., HARRIS, C. M., GILCHRIST, H. G., HENNIN, H. L., RICHARDSON, E. S., DEY, C. J. & SEMENIUK, C. A. D. 2022. Predatory cue use in flush responses of a colonial nesting seabird during polar bear foraging. *Animal Behaviour* 193: 75-90. doi: 10.1016/j.anbehav.2022.08.009

BARR, J. R., GREEN, M. C., DEMASO, S. J. & HARDY, T. B. 2018. Detectability and visibility biases associated with using a consumer-grade unmanned aircraft to survey nesting colonial waterbirds. *Journal of Field Ornithology* 89: 242-257. doi: 10.1111/jofo.12258

BARR, J.R., GREEN, M.C., DEMASO, S.J. & HARDY, T.B. 2020. Drone Surveys Do Not Increase Colony-wide Flight Behaviour at Waterbird Nesting Sites, But Sensitivity Varies Among Species. *Scientific Reports* 10: 3781. doi: 10.1038/s41598-020-60543-z

BARRETO, J., CAJAÍBA, L., TEIXEIRA, J. B., NASCIMENTO, L., GIACOMO, A., BARCELOS, N., FETTERMANN, T. & MARTINS, A. 2021. Drone-Monitoring: Improving the Detectability of Threatened Marine Megafauna. *Drones* 5: 14. doi: 10.3390/drones5010014

BELL, M. & HARBORNE, P. 2019. The use of an Unmanned Aerial Vehicle to census large breeding colonies of black-billed gull (Larus bulleri) and white-fronted tern (Sterna striata) at the Ashburton River/Hakatere River mouth. *Notornis* 66: 95-97. doi: 10.1017/S095927092100037X

BENEMANN, V.R.F., ARAÚJO, L.D., FABBRIS, A.Z., MONTONE, R.C. & PETRY, M.V. 2022. Nesting distribution of Masked Booby *Sula dactylatra* at Trindade Island, western South Atlantic Ocean. *Marine Ornithology* 50: 189-195.

BEVAN, E., WIBBELS, T., NAJERA, B.M., MARTINEZ, M.A., MARTINEZ, L.A., MARTINEZ, F.I., CUEVAS, J.M., ANDERSON, T., BONKA, A.; HERNANDEZ, M.H. 2015. Unmanned aerial vehicles (DRONEs) for monitoring sea turtles in near-shore waters. *Marine Turtle Newsletter* 145: 19–22.

BIRD, C. N., DAWN, A. H., DALE, J. & JOHNSTON, D. W. 2020. A Semi-Automated Method for Estimating Adélie Penguin Colony Abundance from a Fusion of Multispectral and Thermal Imagery Collected with Unoccupied Aircraft Systems. *Remote Sensing* 12: 3692. doi: 10.3390/rs12223692

BISHOP, A. M., BROWN, C. L., CHRISTIE, K. S., KETTLE, A. B., LARSEN, G. D., RENNER, H. M. & YOUNKINS, L. 2022. Surveying cliff-nesting seabirds with unoccupied aircraft systems in the Gulf of Alaska. *Polar Biology* 45: 1703-1714. doi: 10.1007/s00300-022-03101-9

BLIGHT, L.K., BERTRAM, D.F. & KROC, E. 2019. Evaluating drone-based techniques to census an urban-nesting gull population on Canada’s Pacific coast. *Journal of Unmanned Vehicle Systems* 7: 312–324.

BOROWICZ, A., MCDOWALL, P., YOUNGFLESH, C., SAYRE-MCCORD, T., CLUCAS, G., HERMAN, R., FORREST, S., RIDER, M., SCHWALLER, M., HART, T., JENOUVRIER, S., POLITO, M.J., SINGH, H. & LYNCH, H.J. 2018. Multi-modal survey of Adélie penguin mega-colonies reveals the Danger Islands as a seabird hotspot. *Scientific Reports* 8: 1–9. doi: 10.1038/s41598-018-22313-w

BRISSON-CURADEAU, É., BIRD, D., BURKE, C., FIFIELD, D.A., PACE, P., SHERLEY, R.B. & ELLIOTT, K.H. 2017. Seabird species vary in behavioural response to drone census. *Scientific Reports* 7: 1–9. doi: 10.1038/s41598-017-18202-3

BROOKE, S., GRAHAM, D., JACOBS, T., LITTNAN, C., MANUEL, M. & O’CONNER, R. 2015. Testing marine conservation applications of unmanned aerial systems (UAS) in a remote marine protected area. *Journal of Unmanned Vehicle Systems* 3: 237-251. doi: 10.1139/juvs-2015-0011

BURR, P. C., SAMIAPPAN, S., HATHCOCK, L. A., MOORHEAD, R. J. & DORR, B. S. 2019. Estimating Waterbird Abundance on Catfish Aquaculture Ponds Using an Unmanned Aerial System. *Human–Wildlife Interactions* 13. doi: 10.26077/ahd5-na26

CHABOT, D., CRAIK, S.R. & BIRD, D.M. 2015. Population census of a large common tern colony with a small unmanned aircraft. *PLoS ONE* 10: e0122588. doi: 10.1371/journal.pone.0122588

CHEN, X., CHEN, J., CHENG, X., ZHU, L., LI, B. & LI, X. 2021. Retreating Shorelines as an Emerging Threat to Adélie Penguins on Inexpressible Island. *Remote Sensing* 13: 4718. doi: 10.3390/rs13224718

CHOI, H-I., NAM, H-K. & YOON J. 2020. Testing the potential of lightweight drones as a tool for monitoring the status of colonially breeding Saunders's gulls (Saundersilarus saundersi). *Korean Journal of Ornithology* 27: 10-16. doi: 10.30980/kjo.2020.6.27.1.10

CORREGIDOR-CASTRO, A. & VALLE, R.G. 2022. Semi-Automated counts on drone imagery of breeding seabirds using free accessible software. *Ardea* 110: 89–97. doi: 10.5253/arde.v110i1.a7

CORREGIDOR-CASTRO, A., HOLM, T.E. & BREGNBALLE, T. 2021. Counting breeding gulls with unmanned aerial vehicles: camera quality and flying height affects precision of a semi-automatic counting method. *Ornis Fennica* 98: 33–45.

CORREGIDOR-CASTRO, A., RIDDERVOLD, M., HOLM, T. E. & BREGNBALLE, T. 2022. Monitoring colonies of large gulls using UAVs: from individuals to breeding pairs. *Micromachines* 13: 1844. doi: 10.3390/mi13111844

COSTAGLIOLA-RAY, M.M., LIEBER, L., NIMMO-SMITH, W.A.M., MASDEN, E.A., CAPLAT, P., WILSON, J. & O’HANLON, N.J. 2022. To fly or not to fly? Comparing vantage point and uncrewed aerial vehicle surveys for assessments of seabird abundance and fine-scale distribution. *Environmental Impact Assessment Review* 97: 106906. doi: 10.1016/j.eiar.2022.106906

CROFTS, S. & STANWORTH, A. 2020. *Falkland Islands Seabird Monitoring Programme ‐ Annual Report 2019/2020 (SMP27)*. Stanley, Falkland Islands: Falklands Conservation.

DELORD, K., ROUDAUT, G., GUINET, C., BARBRAUD, C., BERTRAND, S. & WEIMERSKIRCH, H. 2015. Kite aerial photography: a low-cost method for monitoring seabird colonies. *Journal of Field Ornithology* 86: 173-179. doi: 10.1111/jofo.12100

DICKENS, J., HOLLYMAN, P.R., HART, T., ET AL. 2021. Developing UAV monitoring of South Georgia and the South Sandwich Islands’ iconic land-based marine predators. Frontiers in Marine Science 8: 630. doi: 10.3389/fmars.2021.654215

DREVER, M. C., CHABOT, D., O'HARA, P. D., THOMAS, J. D., BREAULT, A. & MILLIKIN, R. L. 2015. Evaluation of an unmanned rotorcraft to monitor wintering waterbirds and coastal habitats in British Columbia, Canada. *Journal of Unmanned Vehicle Systems* 3: 256-267. doi: 10.1139/juvs-2015-0019

DULAVA, S., BEAN, W. T. & RICHMOND, O. M. W. 2015. Environmental Reviews and Case Studies: Applications of Unmanned Aircraft Systems (UAS) for Waterbird Surveys. *Environmental Practice* 17: 201-210. doi: 10.1017/S1466046615000186

DUNN, M. J., ADLARD, S., TAYLOR, A. P., WOOD, A. G., TRATHAN, P. N. & RATCLIFFE, N. 2021. Un-crewed aerial vehicle population survey of three sympatrically breeding seabird species at Signy Island, South Orkney Islands. *Polar Biology* 44: 717-727. doi: 10.1007/s00300-021-02831-6

ELLIS-FELEGE, S. N., STECHMANN, T., HERVEY, S., FELEGE, C. J., ROCKWELL, R. F. & BARNAS, A. F. 2022. Nesting Common Eiders (<i>Somateria mollissima</i>) show little behavioral response to fixed-wing drone surveys. *Drone Systems and Applications* 10: 1-14. doi: 10.1139/juvs-2021-0012

ESPÍNDOLA, W. D., CRUZ‐MENDOZA, A., GARRASTAZÚ, A.,ET AL. 2023. Estimating population size of red‐footed boobies using distance sampling and drone photography. *Wildlife Society Bulletin* 47: e1406. doi: 10.1002/wsb.1406

FIRLA, M., MUSTAFA, O., PFEIFER, C., SENF, M. & HESE, S. 2019. INTRASEASONAL VARIABILITY OF GUANO STAINS IN A REMOTELY SENSED PENGUIN COLONY USING UAV AND SATELLITE. ISPRS Ann. Photogramm. *Remote Sensing and Spatial Information Sciences* IV-2/W5: 111-118. doi: 10.5194/isprs-annals-IV-2-W5-111-2019

FRANCIS, R. J., KINGSFORD, R. T. & BRANDIS, K. J. 2022. Using drones and citizen science counts to track colonial waterbird breeding, an indicator for ecosystem health on the Chobe River, Botswana. *Global Ecology and Conservation* 38: e02231. doi: 10.1016/j.gecco.2022.e02231

FRANCIS, R. J., LYONS, M. B., KINGSFORD, R. T. & BRANDIS, K. J. 2020. Counting Mixed Breeding Aggregations of Animal Species Using Drones: Lessons from Waterbirds on Semi-Automation. *Remote Sensing* 12: 1185. doi: 10.3390/rs12071185

FRIXIONE, M. G. & SALVADEO, C. 2021. Drones, Gulls and Urbanity: Interaction between New Technologies and Human Subsidized Species in Coastal Areas. *Drones* 5: 30. doi: 10.3390/drones5020030

FUDALA, K. & BIALIK, R. J. 2022. The use of drone-based aerial photogrammetry in population monitoring of Southern Giant Petrels in ASMA 1, King George Island, maritime Antarctica. *Global Ecology and Conservation* 33: e01990. doi: 10.1016/j.gecco.2021.e01990

GELDART, E.A., BARNAS, A.F., SEMENIUK, C.A.D., ET AL. 2022. A colonial-nesting seabird shows no heart-rate response to drone-based population surveys. *Scientific Reports* 12. doi: 10.1038/s41598-022-22492-7

GIACOMO, A. B. D., BARRETO, J., TEIXEIRA, J. B., OLIVEIRA, L., CAJAÍBA, L., JOYEUX, J. C., BARCELOS, N. & MARTINS, A. S. 2021. Using drones and ROV to assess the vulnerability of marine megafauna to the Fundão tailings dam collapse. *Science of The Total Environ*ment 800: 149302. doi: 10. 1016/j.scitotenv.2021.149302

GOEBEL, M.E., PERRYMAN, W.L., HINKE, J.T., ET AL. 2015. A small unmanned aerial system for estimating abundance and size of Antarctic predators. *Polar Biology* 38: 619–630. doi: 10.1007/s00300-014-1625-4

GRENZDÖRFFER, G.J. 2013. UAS-based automatic bird count of a common gull colony. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* XL-1/W2: 169–174. doi: 10.5194/isprsarchives-XL-1-W2-169-2013

HAN, Y.-G., YOO, S. H. & KWON, O. 2017. Possibility of applying unmanned aerial vehicle (UAV) and mapping software for the monitoring of waterbirds and their habitats. *Journal of Ecology and Environment* 41. doi: 10.1186/s41610-017-0040-5

HARKNESS, P. & SPROGIS, K.R. 2020. Silver gull harassment of humpback whales in Exmouth Gulf, Western Australia. *Marine and Freshwater Research* 72: 584-592. doi: 10.1071/MF20129

HARRIS, M.P., BLACKBURN, J., BUDWORTH, D. & BLACKBURN, A.C. 2019. Sule Skerry – an overspill gannetry from Sule Stack. *SEABIRD* 31: 96-105.

HAYES, M.C., GRAY, P.C., HARRIS, G., ET AL. 2021. Drones and deep learning produce accurate and efficient monitoring of large-scale seabird colonies. Ornithological Applications 123: 1–16. doi: 10.1093/ornithapp/duab022

HINKE, J. T., GIUSEFFI, L. M., HERMANSON, V. R., WOODMAN, S. M. & KRAUSE, D. J. 2022. Evaluating Thermal and Color Sensors for Automating Detection of Penguins and Pinnipeds in Images Collected with an Unoccupied Aerial System. *Drones* 6: 255. doi: 10.3390/drones6090255

HODGSON, J. C., MOTT, R., BAYLIS, S. M., ET AL. 2018. Drones count wildlife more accurately and precisely than humans. *Methods in Ecology and Evolution* 9: 1160-1167. doi: 10.1111/2041-210X.12974HODGSON, J.C., BAYLIS, S.M., MOTT, R., HERROD, A. & CLARKE, R.H. 2016. Precision wildlife monitoring using unmanned aerial vehicles. *Scientific Reports* 6: 1–7. doi: 10.1038/srep22574

IRIGOIN-LOVERA, C., LUNA, D.M., ACOSTA, D.A. & ZAVALAGA, C.B. 2019. Response of colonial Peruvian guano birds to flying UAVs: effects and feasibility for implementing new population monitoring methods. *PeerJ* 7: e8129. doi: 10.7717/peerj.8129

JAGIELSKI, P. M., DEY, C. J., GILCHRIST, H. G., RICHARDSON, E. S., LOVE, O. P. & SEMENIUK, C. A. D. 2021. Polar bears are inefficient predators of seabird eggs. *Royal Society Open Science* 8. doi: 10.1098/rsos.210391

JONES, F.M., ARTETA, C., ZISSERMAN, A., LEMPITSKY, V., LINTOTT, C.J. & HART, T. 2020. Processing citizen science- and machine-annotated time-lapse imagery for biologically meaningful metrics. *Scientific Data* 7: 1–15. doi: 10.1038/s41597-020-0442-6

KELLENBERGER, B., VEEN, T., FOLMER, E. & TUIA, D. 2021. 21 000 birds in 4.5 h: efficient large-scale seabird detection with machine learning. *Remote Sensing in Ecology and Conservation* 7: 445-460. doi: 10.1002/rse2.200

KIM, J-U., KIM, Y., OH, Y., KIM, H-C. & KIM, J-H. 2022. Antarctic Ecosystem Recovery Following Human-Induced Habitat Change: Recolonization of Adélie Penguins (Pygoscelis adeliae) at Cape Hallett, Ross Sea. *Diversity* 15. doi: 10.3390/d15010051

KORCZAK-ABSHIRE, M., KIDAWA, A., ZMARZ, A., STORVOLD, R., KARLSEN, S., RODZEWICZ, M., CHWEDORZEWSKA, K. & ZNÓJ, A. 2016. Preliminary study on nesting Adélie penguins disturbance by unmanned aerial vehicles. *CCAMLR Sci*ence 23: 1-16.

KORCZAK-ABSHIRE, M., ZMARZ, A., RODZEWICZ, M., KYCKO, M., KARSZNIA, I. & CHWEDORZEWSKA, K.J. 2019. Study of fauna population changes on Penguin Island and Turret Point Oasis (King George Island, Antarctica) using an unmanned aerial vehicle. *Polar Biology* 42: 217–224. doi: 10.1007/s00300-018-2379-1

KRAUSE, D.J., HINKE, J.T., GOEBEL, M.E. & PERRYMAN, W.L. 2021. Drones minimize Antarctic predator responses relative to ground survey methods: an appeal for context in policy advice. *Frontiers in Marine Science* 8. doi: 10.3389/fmars.2021.648772

LIEBER, L., FÜCHTENCORDSJÜRGEN, C., HILDER, R. L., REVERING, P. J., SIEKMANN, I., LANGROCK, R. & NIMMO‐SMITH, W. A. M. 2022. Selective foraging behavior of seabirds in small‐scale slicks. *Limnology and Oceanography Letters* 8: 286-294. doi: 10.1002/lol2.10289

LIEBER, L., LANGROCK, R. & NIMMO-SMITH, W.A.M. 2021. A bird’s-eye view on turbulence: seabird foraging associations with evolving surface flow features. *Proceedings of the Royal Society B*. 288: rspb.2021.0592, 20210592. doi: 10.1098/rspb.2021.0592

LIEBER, L., NIMMO-SMITH, W.A.M., WAGGITT, J.J. & KREGTING, L. 2019. Localised anthropogenic wake generates a predictable foraging hotspot for top predators*. Communications Biology* 2: 123. doi: 10.1038/s42003-019-0364-z

LIU, Y., SHAH, V., BOROWICZ, A., WETHINGTON, M., STRYCKER, N., FORREST, S., LYNCH, H. & SINGH, H. 2020. Towards Efficient Machine Learning Methods for Penguin Counting in Unmanned Aerial System Imagery. 2020 IEEE/OES Autonomous Underwater Vehicles Symposium (AUV) 1-7. doi: 10.1109/AUV50043.2020.9267936

LOUREIRO, N.S., REIS, E., DIAS, D. & VEIGA, A. 2021*.* Is Sula sula breeding in the cliffs of Baía do Inferno, Santiago Island, Cabo Verde? *Zoologia Caboverdiana* 9 : 14-16.

MAGNESS, D.R., ESKELIN, T., LAKER, M. & RENNER, H.M. 2019. Evaluation of small unmanned aerial systems as a census tool for Aleutian Tern Onychoprion aleuticus colonies. *Marine Ornithology* 47: 11–16.

MALLORY, M.L., DEY, C.J., MCINTYRE, J., ET AL. 2020. Long-term declines in the size of Northern Fulmar (Fulmarus glacialis) colonies on eastern Baffin Island, Canada. *Arctic* 73: 187–194.

MAPES, K.L., PRICOPE, N.G., BAXLEY, J.B., SCHAALE, L.E. & DANNER, R.M. 2020. Thermal imaging of beach-nesting bird habitat with unmanned aerial vehicles: considerations for reducing disturbance and enhanced image accuracy. *Drones* 4: 12. doi: 10.3390/drones4020012

MATTERN, T., REXER-HUBER, K., PARKER, G., ET AL. 2021. Erect-crested penguins on the Bounty Islands: population size and trends determined from ground counts and drone surveys. *Notornis* 68: 37–50. doi: 10.6084/m9.figshare.19709476

MCCLELLAND, G.T., BOND, A.L., SARDANA, A. & GLASS, T. 2016. Rapid population estimate of a surface-nesting seabird on a remote island using a low-cost unmanned aerial vehicle. *Marine Ornithology* 44: 215–220.

MCKELLAR, A. E. 2022. Patterns of inter- and intraspecific nest dispersion in colonies of gulls and grebes based on drone imagery. *Journal of Field Ornithology* 93:4. doi: 10.5751/JFO-00099-930204

MCKELLAR, A. E., SHEPHARD, N. G. & CHABOT, D. 2021. Dual visible‐thermal camera approach facilitates drone surveys of colonial marshbirds. *Remote Sensing in Ecology and Conservation* 7: 214-226. doi: 10.1002/rse2.183

MULLER, C. G., CHILVERS, B. L., BARKER, Z., BARNSDALE, K. P., BATTLEY, P. F., FRENCH, R. K., MCCULLOUGH, J. & SAMANDARI, F. 2019. Aerial VHF tracking of wildlife using an unmanned aerial vehicle (UAV): comparing efficiency of yellow-eyed penguin (*Megadyptes antipodes*) nest location methods. *Wildlife Research* 46: 145-153, 9. doi: 10.1071/WR17147

MUSTAFA, O., BRAUN, C., ESEFELD, J., ET AL. 2019. Detecting Antarctic seals and flying seabirds by UAV. *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences* V-2/W5, 141–148. doi: 10.5194/isprs-annals-IV-2-W5-141-2019

MUSTAFA, O., ESEFELD, J., GRÄMER, H., ET AL. 2017. *Monitoring Penguin Colonies in the Antarctic Using Remote Sensing Data*. Dessau-Roßlau, Germany: Umweltbundesamt. [Accessed at [http://www.umweltbundesamt.de/publikationen on 31 March 2022](http://www.umweltbundesamt.de/publikationen%20on%2031%20March%202022).]

OOSTHUIZEN, W.C., KRÜGER, L., JOUANNEAU, W. & LOWTHER, A.D. 2020. Unmanned aerial vehicle (UAV) survey of the Antarctic shag (Leucocarbo bransfieldensis) breeding colony at Harmony Point, Nelson Island, South Shetland Islands. *Polar Biology* 43: 187–191. doi: 10.1007/s00300-019-02616-y

PARK, M. 2020. *Spatial distribution analysis of Black-legged Kittiwakes and Northern Fulmars in Svalbard coastal cliffs using remotely piloted aircraft system*. Master’s Thesis. Seoul, South Korea: Seoul National University.

PARKER, G.C. & REXER-HUBER, K. 2020. *Drone-based Salvin’s Albatross Population Assessment: Feasibility at the Bounty Islands*. Dunedin, New Zealand: Conservation Services Programme, Department of Conservation, pp 19.

PARKER G.C., ELLIOTT G., WALKER K., REXER-HUBER K. 2022. *Gibson’s albatross and white-capped albatross in the Auckland Islands 2021–22.* Dunedin, New Zealand: Conservation Services Programme, Department of Conservation, pp 26.

PARKER, G.C. & REXER-HUBER, K. 2021. *Foveaux and Otago shag population census methods: drone and camera trials.* Dunedin, New Zealand: Conservation Services Programme, Department of Conservation.

PERRINS, C., PADGET, O., O’CONNELL, M., BROWN, R., BÜCHE, B., EAGLE, G., RODEN, J., STUBBINGS, E. & WOOD, M.J. 2019. A census of breeding Manx Shearwaters *Puffinus puffinus* on the Pembrokeshire Islands of Skomer, Skokholm and Midland in 2018. *SEABIRD* 31:106-118.

PFEIFER, C., BARBOSA, A., MUSTAFA, O., PETER, H.-U., RÜMMLER, M.-C. & BRENNING, A. 2019. Using fixed-wing UAV for detecting and mapping the distribution and abundance of penguins on the South Shetlands Islands, Antarctica. *Drones* 3: 39. doi: 10.3390/drones3020039

PFEIFER, C., RÜMMLER, M.-C. & MUSTAFA, O. 2021. Assessing colonies of Antarctic shags by unmanned aerial vehicle (UAV) at South Shetland Islands, Antarctica. *Antarctic Science* 33: 133-149. doi: 10.1017/S0954102020000644

POLENSKY, J., REGENDA, J., ADAMEK, Z. & CISAR, P. 2022. Prospects for the monitoring of the great cormorant (Phalacrocorax carbo sinensis) using a drone and stationary cameras. *Ecological Informatics* 70: 101726. doi: 10.1016/j.ecoinf.2022.101726

PONTALTI, M. & BARRETO, A. S. 2022. Use of Unnamed Aerial Vehicles (UAVs) to monitor marine megafauna strandings in beach monitoring programs. *Journal of Coastal Conservation* 26. doi: 10.1007/s11852-022-00924-w

RAHMAN, D. A., SITORUS, A. B. Y. & CONDRO, A. A. 2022. From Coastal to Montane Forest Ecosystems, Using Drones for Multi-Species Research in the Tropics. *Drones* 6: 6. doi: 10.3390/drones6010006

RATCLIFFE, N., GUIHEN, D., ROBST, J., CROFTS, S., STANWORTH, A. & ENDERLEIN, P. 2015. A protocol for the aerial survey of penguin colonies using UAVs. *Journal of Unmanned Vehicle Systems* 3: 95–101. doi: 10.1139/juvs-2015-0006

REINTSMA, K.M., MCGOWAN, P.C., CALLAHAN, C., ET AL. 2018. Preliminary evaluation of behavioral response of nesting waterbirds to small unmanned aircraft flight. *Waterbirds* 41: 326–331. doi: 10.1675/063.041.0314

REXER-HUBER K., PARKER K.A., PARKER G.C. 2020. *Campbell Island Seabirds: Operation Endurance November 2019*. Dunedin, New Zealand: Marine and Species Threats, Department of Conservation, pp. 23.

REXER-HUBER, K. & PARKER, G. 2019. *Bounty Islands drone trials: feasibility for population assessment of NZ fur seal*. Dunedin, New Zealand: Conservation Services Programme, Department of Conservation, pp 17.

ROMÁN, A., NAVARRO, G., CABALLERO, I. & TOVAR-SÁNCHEZ, A. 2022. High-spatial resolution UAV multispectral data complementing satellite imagery to characterize a chinstrap penguin colony ecosystem on deception island (Antarctica). *GIScience & Remote Sensing* 59: 1159-1176. doi 10.1080/15481603.2022.2101702

RÜMMLER, M.-C., ESEFELD, J., PFEIFER, C. & MUSTAFA, O. 2021. Effects of UAV overflight height, UAV type, and season on the behaviour of Emperor penguin adults and chicks. *Remote Sensing Applications: Society and Environment* 23: 100558. doi: 10.1016/j.rsase.2021.100558

RÜMMLER, M.-C., MUSTAFA, O., MAERCKER, J., PETER, H.-U. & ESEFELD, J. 2016. Measuring the influence of unmanned aerial vehicles on Adélie penguins. *Polar Biology* 39: 1329–1334. doi: 10.1007/s00300-015-1838-1

RÜMMLER, M.-C., MUSTAFA, O., MAERCKER, J., PETER, H.-U. & ESEFELD, J. 2018. Sensitivity of Adélie and Gentoo penguins to various flight activities of a micro UAV. *Polar Biology* 41: 2481–2493. doi: 10.1007/s00300-018-2385-3

RÜMMLER, M.-C., ESEFELD, J., HALLABRIN, M. T., PFEIFER, C. & MUSTAFA, O. 2021a. Emperor penguin reactions to UAVs: First observations and comparisons with effects of human approach. *Remote Sensing Applications: Society and Environment* 23: 100545. doi: 10.1016/j.rsase.2021.100545

RUSH, G.P., CLARKE, L.E., STONE, M. & WOOD, M.J. 2018. Can drones count gulls? Minimal disturbance and semiautomated image processing with an unmanned aerial vehicle for colony-nesting seabirds. *Ecology and Evolution* 8: 12322–12334. doi: 10.1002/ece3.4495

SARDÀ‐PALOMERA, F., BOTA, G., VIÑOLO, C., ET AL. 2012. Fine-scale bird monitoring from light unmanned aircraft systems. *Ibis* 154: 177–183. doi: 10.1111/j.1474-919X.2011.01177.x

SARDÀ-PALOMERA, F., BOTA, G., PADILLA, N., BROTONS, L. & SARDÀ, F. 2017. Unmanned aircraft systems to unravel spatial and temporal factors affecting dynamics of colony formation and nesting success in birds. *Journal of Avian Biology* 48: 1273-1280. doi: 10.1111/jav.01535

SCARTON, F. & VALLE, R. 2021. Drone assessment of habitat selection and breeding success of Gull-billed Tern *Gelochelidon nilotica* nesting on low-accessibility sites: a case study. *Rivista Italiana di Ornitologia* 90. doi: 10.4081/rio.2020.475

SCARTON, F. & VALLE, R. G. 2022. Comparison of drone vs. ground survey monitoring of hatching success in the black-headed gull (*Chroicocephalus ridibundus*). *Ornithology Research* 30: 271-280. doi: 10.1007/s43388-022-00112-2

SHAH, K., BALLARD, G., SCHMIDT, A. & SCHWAGER, M. 2020. Multidrone aerial surveys of penguin colonies in Antarctica. *Science Robotics* 5: eabc3000.

SLINGSBY, J., SCOTT, B. E., KREGTING, L., MCILVENNY, J., WILSON, J., YANEZ, M., LANGLOIS, S. & WILLIAMSON, B. J. 2022. Using Unmanned Aerial Vehicle (UAV) Imagery to Characterise Pursuit-Diving Seabird Association With Tidal Stream Hydrodynamic Habitat Features. *Frontiers in Marine Science* 9. doi: 10.3389/fmars.2022.820722

STANWORTH, A., BERTRAM, E. WINNARD, M. AND IRELAND, L. 2020. *Report on a visit to Falklands Conservation owned North, Saddle, Cliff Knob, Ship, Coffin and Beef Islands in 2019*. Falkland Islands: Falklands Conservation.

STRYCKER, N., BOROWICZ, A., WETHINGTON, M., FORREST, S., SHAH, V., LIU, Y., SINGH, H. & LYNCH, H.J. 2021. Fifty-year change in penguin abundance on Elephant Island, South Shetland Islands, Antarctica: results of the 2019–20 census. *Polar Biology* 44: 45–56. doi: 10.1007/s00300-020-02774-4

STRYCKER, N., WETHINGTON, M., BOROWICZ, A., FORREST, S., WITHARANA, C., HART, T. & LYNCH, H. J. 2020. A global population assessment of the Chinstrap penguin (Pygoscelis antarctica). *Scientific Reports* 10. doi: 10.1038/s41598-020-76479-3

TALAVERA, L., COSTAS, S. & FERREIRA, Ó. 2022. A new index to assess the state of dune vegetation derived from true colour images. *Ecological Indicators* 137: 108770. doi: 10.1016/j.ecolind.2022.108770

THOMSON, E. R., SPIEGEL, M. P., ALTHUIZEN, I. H. J., BASS, P., CHEN, S., CHMURZYNSKI, A., HALBRITTER, A. H., HENN, J. J., JÓNSDÓTTIR, I. S., KLANDERUD, K., LI, Y., MAITNER, B. S., MICHALETZ, S. T., NIITTYNEN, P., ROOS, R. E., TELFORD, R. J., ENQUIST, B. J., VANDVIK, V., MACIAS-FAURIA, M. & MALHI, Y. 2021. Multiscale mapping of plant functional groups and plant traits in the High Arctic using field spectroscopy, UAV imagery and Sentinel-2A data. *Environmental Research Letters* 16: 055006. doi: 10.1088/1748-9326/abf464

TOVAR-SÁNCHEZ, A., ROMÁN, A., ROQUE-ATIENZA, D. & NAVARRO, G. 2021. Applications of unmanned aerial vehicles in Antarctic environmental research. *Scientific Reports* 11. doi: 10.1038/s41598-021-01228-zVALLE, R.G. & SCARTON, F. 2021a. Drone-conducted counts as a tool for the rapid assessment of productivity of Sandwich Terns (Thalasseus sandvicensis). *Journal of Ornithology* 162: 621-628. doi: 10.1007/s10336-020-01854-w

VALLE, R. G. & SCARTON, F. 2021b. Monitoring the hatching success of gulls laridae and terns Sternidae: A comparison of ground and drone methods. *Acta Ornithologica* 56: 241-254. doi: 10.3161/00016454AO2021.56.2.010

VILLEGAS, P., MENA, L., CONSTANTINE, A., VILLALBA, R. & OCHOA, D. 2018. Data imaging acquisition and processing as a methodology for estimating the population of frigates using UAVs. *2018 IEEE ANDESCON* 1–4. doi: 10.1109/ANDESCON.2018.8564660

WEIMERSKIRCH, H., PRUDOR, A. & SCHULL, Q. 2018. Flights of drones over sub-Antarctic seabirds show species- and status-specific behavioural and physiological responses. *Polar Biology* 41: 259–266. doi: 10.1007/s00300-017-2187-z

WESTON, M. A., O’BRIEN, C., KOSTOGLOU, K. N. & SYMONDS, M. R. E. 2020. Escape responses of terrestrial and aquatic birds to drones: Towards a code of practice to minimize disturbance. *Journal of Applied Ecology* 57: 777-785. doi: 10.1111/1365-2664.13575

WETHINGTON, M., FLYNN, C., BOROWICZ, A. & LYNCH, H. J. 2023. Adélie penguins north and east of the ‘Adélie gap’ continue to thrive in the face of dramatic declines elsewhere in the Antarctic Peninsula region. *Scientific Reports* 13. doi: 10.1038/s41598-023-29465-4

YORIO, P., POZZI, L., HERRERA, G., PUNTA, G., SVAGELJ, W. S. & QUINTANA, F. 2020. Population trends of Imperial Cormorants (Leucocarbo atriceps) in northern coastal Argentine Patagonia over 26 years. *Emu - Austral Ornithology* 120: 114-122. doi: 10.1080/01584197.2020.1730192

ZMARZ, A., KORCZAK-ABSHIRE, M., STORVOLD, R., RODZEWICZ, M. & KĘDZIERSKA, I. 2015. INDICATOR SPECIES POPULATION MONITORING IN ANTARCTICA WITH UAV. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* XL-1/W4: 189-193. doi: 10.5194/isprsarchives-XL-1-W4-189-2015

ZMARZ, A., RODZEWICZ, M., DĄBSKI, M., KARSZNIA, I., KORCZAK-ABSHIRE, M. & CHWEDORZEWSKA, K. J. 2018. Application of UAV BVLOS remote sensing data for multi-faceted analysis of Antarctic ecosystem. *Remote Sensing of Environment* 217: 375-388. doi: 10.1016/j.rse.2018.08.031