Recommendations for the use of conservation detection dogs in seabird research: a thematic analysis

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Abstract

Conservation detection dog handler teams (CDDHTs) offer many potential benefits to the world of conservation. Seabird populations are an important component of marine ecosystems. However, they are threatened by several anthropogenic activities, including the introduction of invasive species. Although CDDHT can support seabird conservation through invasive species management efforts and population assessments, they are under-utilised. A lack of methodological standardisation within CDDHT work and the under-publishing of their use within seabird research leads to difficulties in conducting new CDDHT seabird-related studies due to an inability to learn from previous research. This study aimed to address these shortcomings by investigating the techniques and methods used by those actively working with, or planning to work with, CDDHT on a seabird project to better understand them, and propose best practices in the field. Seven professionals who have used, or will use, CDDHT as part of a seabird project (four handlers, three ecologists/ researchers) participated in structured written surveys which were thematically analysed. Five superordinate themes emerged from the survey data: Training, Location, Role of Handler, Wildlife Considerations, and Dog Selection Criteria, with the first two themes having several subordinate themes. A summary of best practices was developed from the findings, with notable recommendations including preparation across all project elements, networking with other professionals, and making judgments on the use of techniques like discrimination and field trials based on the specific project and dog(s). These results can serve to benefit future seabird studies involving CDDHT as well as supporting the development of standardisation in the CDDHT field.

Introduction

Conservation detection dogs (CDDs) are defined as working dogs *Canis familiaris* that use their exceptional olfactory abilities (Kokocińska-Kusiak *et al.* 2021) to support conservation projects (MacKay *et al*. 2008; Helton, 2009; Woollett *et al*. 2013) by operating alongside a human handler to create a conservation detection dog handler team (CDDHT) (Richards *et al.* 2021). CDDHTs can be complementary to current animal monitoring techniques, such as capture-mark-recapture, camera trapping, playback surveys and other surveys. Indeed, CDDHTs can cover large distances in short timespans and find many samples, often greater numbers than a human observer working alone might encounter (Browne *et al.* 2006; MacKay *et al.* 2008; Kerley 2010; Grimm-Seyfarth & Klenke 2018; Stanhope & Sloan 2019). CDDHTs are also unaffected by sampling bias arising from use of visual information (MacKay *et al.* 2008; Kerley 2010), which can also be invasive (Browne *et al.* 2006; Kerley 2010; Grimm-Seyfarth & Klenke 2018; Richards 2018). However, CDDHTs are costly in time and money, as it can take months or years to train a CDDHT and the CDD must be maintained through food, housing, transport and training (MacKay *et al.* 2008; Kerley 2010). Additionally, acquiring appropriate training samples can be practically and legally challenging, depending on the target species (MacKay *et al.* 2008; Kerley 2010). Despite these limitations, CDD methodology has been used worldwide (Grimm-Seyfarth *et al.* 2021) for more than a hundred years (Hill & Hill 1987), detecting over 400 animal species including 114 bird species, and nine seabirds (Grimm-Seyfarth *et al.* 2021).

Seabirds are an important component of both marine and terrestrial ecosystems (Schreiber & Burger 2001). On one hand, due to their dependence on the marine environment for trophic resources and their high ranking in the marine food web, seabirds are considered good bioindicators of the health and functioning of the marine environment. On the other hand, because they breed on land, their guano, food remains and other components (egg remains, carcasses, etc.) improve the fertility of marine and terrestrial areas around their colonies (Croxall *et al.* 2012; Paleczny *et al.* 2015; Dias *et al.* 2019; Rodríguez *et al.* 2019). Due to their biology, they are exposed to threats both on land and at sea and therefore, they are also one of the most at-risk groups of birds globally, with 70% of seabird populations suffering declines (Grémillet & Boulinier 2009; Paleczny *et al.* 2015; Rodríguez *et al.* 2019). Threats to seabirds include invasive alien species like rats and cats, fisheries bycatch, overfishing, climate change, hunting and trapping, disturbance, problematic native species, energy production and mining and building developments (Spatz *et al.* 2017; Dias *et al.* 2019). Population estimates play a key role in understanding causes of their decline as well as their conservation management (Paleczny *et al.* 2015). One of the most basic aspects of obtaining seabird population estimates involves finding breeding locations and censusing breeding pairs. However, many seabird species employ cryptic behaviours to limit predation and piracy, such as nesting on remote islands or in inaccessible areas, such as within burrows and crevices or on cliffs (Schreiber & Burger, 2001), making them difficult for human researchers to detect and monitor.

To produce and maintain an operational CDDHT to a high standard, both the dog and handler require extensive training. There are numerous ways to train a detection dog, but generally the process consists of search development, training a passive indication, imprinting on the target odour and any necessary discrimination training. Discrimination training is undertaken to ensure a CDD can correctly discriminate trained odours from non-trained odours (Porritt *et al.* 2015). Non-trained odours can include training aids such as nitrile gloves and storage jars, as well as other odours the dog may experience in the field. This may include scents that are similar to the target odour, for example, a non-target species of seabird.

How long training a detection dog takes is variable, and dogs also require continuation training throughout their working careers. The length of time it takes to train the handler will also vary depending on the ability of the selected individual to recognise changes in behaviour and indication of their detection dog (DeMatteo *et al.* 2019). The pairing of dog handler teams is also important, and time must be given for new teams to bond as this can impact detection performance (Jamieson 2018).

The time taken to search a given area depends on a variety of factors including terrain, temperature, humidity, wind direction and speed. The location of the target odour can impact how intensely the dog needs to search, potentially increasing search time, e.g. if the target odour is buried (Osterkamp, 2020).

CDDHTs can help overcome difficulties in conducting seabird population surveys due to their lack of reliance on visual information and ability to cover large areas more quickly than humans (Kerley 2010). In the published literature, however, there are limited examples of CDDHTs being deployed to assist seabird conservation efforts. CDDHTs are most commonly used as part of biosecurity measures to avoid the introduction of invasive species and for invasive species detection during and following eradication efforts (Russell *et al.* 2008; Bellingham *et al.* 2010; Pierce *et al.* 2015; Robinson *et al.* 2015; Springer 2018; Phillips 2019; Robinson & Gadd 2020). In the few cases where CDDHTs have been actively used to detect seabirds, they have found nests or burrows of species like Little Penguin *Eudyptula minor* (Cargill *et al.* 2022), Band-rumped Storm-petrel *Hydrobates castro* (Galase 2019), Black Petrel *Procellaria parkinsoni* (Bell *et al.* 2014), and Manx Shearwater *Puffinus puffinus* (Bolton *et al.* 2021). Although CDDHTs can be costly to hire, it is important to understand why they have been underutilised in seabird conservation management given their potential benefits.

Perhaps a critical concern in utilising CDDHTs for seabird conservation is the lack of methodological consistency observed across studies. This inconsistency hampers the ability to evaluate the effectiveness of this approach and emphasises the need for its standardisation (Bennett 2015; Johnen *et al.* 2017; Hayes *et al.* 2018; Otto *et al.* 2019). Persistent problems that occur in CDD studies include a lack of methodological detail on training and searches (Johnen *et al.* 2017; Bennett 2020), small sample sizes when assessing CDDHT performance (Lazarowski *et al.* 2020; Whitehouse-Tedd *et* *al.* 2021), and inconsistency regarding the measures used to evaluate a CDD's performance (Johnen *et al.* 2017; Hayes *et al.* 2018). Furthermore, it appears that much of the literature regarding practical seabird conservation, both including and excluding CDDHTs, goes unpublished, as exampled by the following studies which refer to and use findings and data from unpublished work: Russell *et al.* 2008; Bellingham *et al.* 2010; Bell *et al.* 2014; Parker & Rexer-Huber 2015, 2016; Robinson *et al.* 2015; VanderWerf & Young 2017; Cargill *et al.* 2022. This means that researchers are prevented from learning from previous studies and may be making the same mistakes as others, thus exacerbating the need to move towards standardisation of survey methods used.

Although there are literature reviews and books that outline key aspects of using working dogs including CDD (MacKay *et al.* 2008; Helton 2009; Beebe *et al.* 2016; Lazarowski *et al.* 2020), we were unable to find any examples of thematic analyses or qualitative assessments of methodologies within the CDD literature. Gathering insights from professionals who work with CDDs for seabird projects would allow for the assessment of methods and techniques that are currently used in the field as well as the rationale for their use. Furthermore, consolidating this information could help researchers, environmental non-governmental organisations, statutory conservation bodies or developers considering using a CDDHT in a seabird project to make decisions regarding selecting a qualified team, and improve their understanding and support of the CDDHT method. In this study, structured written interviews were conducted with professionals who have used, or plan to use, CDDHTs in seabird conservation. Our aim was to explore different aspects of project design and the utilisation of CDDs, with the goal of developing best practice recommendations.

Methods

Design and ethical considerations

This research employed a reflexive qualitative design, which recognises the researcher's role within the research process and acknowledges how their prior experiences can shape the results (Haynes 2012). The author in charge of data analysis (BMcK) was new to the field of CDD and seabird conservation. This author was selected to reduce bias whilst the themes were then reviewed by all other authors, comprising qualified CDD handlers and seabird conservationists, to verify the results. An inductive thematic approach was applied, as there is limited research in this area. Results were interpreted with no preconceptions or expectations of how the CDDHTs would handle a project. Although specific questions were set out in the survey (see Appendix 1), all questions were open-ended and designed to gather wide-ranging information on all different relevant aspects of a project involving CDDHTs. The questions were based on the corresponding author's (CF) own knowledge and experience of conducting a CDD search, whilst also allowing participants to add any additional thoughts or input. This study was conducted and reported in compliance with the Standards for Reporting Qualitative Research, which aim to improve the transparency of qualitative research by providing standards for authors and editors to follow when developing a paper (O'Brien *et al.* 2014).

Regarding ethical considerations, participants were informed via the questionnaire that all data would be anonymised, and no data were collected that involved personal information or that which could cause distress or discomfort to participants. Participants could revoke their participation in the study at any time and contact information for one of the study's authors was provided for any questions that arose. All participants were asked to take part in the write up of the results within this manuscript. Risk to the participants of this study was low, and so an ethical review was not deemed necessary.

Participants

The inclusion criteria for the study were that participants were either CDD handlers, ecologists, or seabird researchers who had used, or planned to use, dogs to detect any seabird species. After a Google Search in May 2021 only produced one record of a dog being used for seabird detection, the social media platforms Twitter (now X), Facebook and LinkedIn were used to advertise the study, and known professionals were approached via email to enquire about participating. No material rewards were offered for participation; participants gained an opportunity to contribute to the development of the field.

Data Collection

Data were collected through structured written surveys (i.e. set questions) sent out to all participants over five months from October 2021 to February 2022 (see Appendix 1). A range of questions were created by authors (CF, PK, RC) that considered both research and dog training experience. The questions selected for this study aimed to cover the majority of issues and decision-making processes that the authors had experienced in previous projects. Surveys were formatted as Microsoft® Word documents that could be completed and returned to the authors via email. The survey comprised eight sections, each focusing on a different aspect of the project and CDD use: project introduction, dog selection, imprinting, search styles, project location, communication between stakeholders, welfare concerns, and any other comments.

Data Analysis Procedure

The six-stage dynamic and cyclical thematic analysis process described in detail by Braun & Clarke (2006) was followed to analyse the data. Although qualitative research is limited in the context of CDDs, thematic analysis has been used in other animal-based studies including Balzani and Hanlon (2020) on farm animal welfare, Holland *et al.* (2021) on dog ownership during the first UK COVID-19 lockdown, and Rutter *et al.* (2022) on becoming a CDD handler, with similar goals to this study regarding informing best practice in animal science. Data analysis was facilitated using the qualitative research software Weft QDA Version 1.0.1. The process of thematic analysis took place as per McKeague & Maguire (2021):

1. Familiarisation with the data contents.
2. Noting of basic recurring themes and relevant quotes for initial data coding.
3. Developing a list of emerging themes based on these codes.
4. Reviewing of emergent themes to identify superordinate versus subordinate themes as well as remove and edit less relevant themes.
5. Finalising list of master themes by defining and naming them. Conduct additional review of master themes by secondary authors for increased data trustworthiness.
6. Writing-up analysis to provide argument for the relevance of the themes to the research questions.

Results

Sample Characteristics

The sample of seven respondents had conducted projects across five countries including the United States, United Kingdom, Canada, Republic of Ireland and the Republic of Cabo Verde. In total nine surveys were sent via email, and seven were returned completed. Two of these participants stemmed from Twitter where our advertisement to participate received over 6,200 impressions and 39 retweets. The largest source of participants was through authors reaching out to possible interested parties via email ($N_{respondents} = 5$).

All respondents were either ecologists/researchers or CDD handlers working on seabird projects, with a target of seabird conservation. Project partners included individuals from universities, government agencies, and charities (see Table 1). Northern Storm-petrel (Hydrobatidae) species were the most common species targeted by CDDHT searches (N = 5), along with other members of the Procellariidae family and invasive rat species (*Rattus rattus*, *Rattus norvegicus*). More than half of participants (N = 4) were CDD handlers who trained and used dogs, with the remainder (N = 3) being ecologists or researchers who took part in study design and implementation. Dog characteristics varied between projects, with the average age of dogs being five years, and Springer Spaniel being the most common breed (Table 1).

Table 1. Characteristics of the participants in our study who have used or plan to use conservation detection dog handling teams in seabird conservation, as well as their respective projects.

ID	Target Species	Respondent Role	Dog Traits	Project Partners	Project Location
S1 (N.B. same project as S4)	Fork-tailed Storm-petrel *Hydrobates furcatus,* Leach's Storm-petrel *Hydrobates leucorhous,* Black Rat *Rattus rattus*, Norway Rat *Rattus norvegicus*	Ecologist or researcher	13-year-old, Labrador mix	Parks Canada, Rogue Detection Teams	Haida Gwaii, British Columbia, Canada
S2 (N.B. proposed project)	Wedge-tailed Shearwater *Ardenna pacifica,* Hawaiian Petrel *Pterodroma sandwichensis,* Newell's Shearwater *Puffinus newelli*	Dog handler and trainer	3-year-old Dutch Shepherd mix, 1-year-old Labrador, 4-year-old Labrador, 4-year-old Australian Shepherd, 6-year-old Australian Shepherd	Subcommittee of the Kauai Seabird Habitat Conservation Plan participants group	Oahu and Kauai, Hawaii, United States
S3	European Storm-petrel *Hydrobates pelagicus*	Dog handler and trainer	3-year-old Springer and Cocker Spaniel mix, 20-month-old Malinois, three additional dogs (Unknown traits)	K9 Manhunt, ScentWork Scotland, NatureScot, Isle of May Bird Observatory, UK Centre For Ecology & Hydrology	Isle of May, Anstruther, Scotland
S4 (N.B. same project as S1)	Fork-tailed Storm-petrel *Hydrobates furcatus*, Leach's Storm-petrel *Hydrobates leucorhous,* Black rat *Rattus rattus,* Norway rat *Rattus norvegicus*	Dog handler and trainer	13-year-old Labrador mix	Parks Canada, Rogue Detection Teams, Environment Canada	Haida Gwaii, British Columbia, Canada
S5	Fea's Petrel *Pterodroma feae*	Ecologist or researcher	4-year-old Springer Spaniel	University of Barcelona, Associação Projecto Vitó	Islands of Fogo, Santo Antão, São Nicolau and Santiago, Republic of Cabo Verde

S6	Band-rumped Storm-petrel *Hydrobates castro*	Ecologist or researcher	Not stated	Center for Environmental Management of Military Lands	Hawaii island, Hawaii, United States
S7	Manx Shearwater *Puffinus puffinus*	Dog handler and trainer	8-year-old Springer Spaniel	Agri-Food and Biosciences Institute BirdWatch Ireland KRC Ecological Conservation Detection Dogs Northern Ireland	Various islands, Republic of Ireland

Themes Emerging from Data

This section defines, describes, and illustrates all themes emerging from the data with the use of representative quotations from the surveys (see Table 2). In the post survey analysis, five main superordinate themes were identified with two of these themes encompassing several subordinate themes.

Theme 1. The training of a CDD prior to and during a project

The first half of the survey included several questions on key aspects of CDD training. As such, participants described how they approached the specific training areas that were addressed in their respective projects. Of all the questions asked and topics broached, training was the theme participants provided the greatest detail on and was the main element of a project that they would change in future studies with a focus on search methods. For example: training the dog to search while on a longline or leash ('More on long line free searches and check searches'; S3), preparing for field trials and the transport to the project location in advance ('What the boats were like and the landing sites like'; S7), and access to greater quantities of fresh scent samples for imprinting ('We would have encouraged… that fresh feathers be collected en-masse… This would have fast tracked the efforts on the ground'; S4).

> Question: Is there any particular training you would focus on if running the project again?
> *If doing again, would avoid training on islands with dense Storm-petrel colonies.*
> (S1)

> Question: Is there anything else you think would be important for a scientist taking on a dog team, or a dog team beginning work on a seabird project to know?

Allow dogs to sniff appropriately handled birds for a quick sniff and reward and have materials from seasons prior to deploying dogs stored appropriately to be able to send.

(S4)

T1.1. Gathering and storing scent samples for training

Samples used for training, specifically imprinting, often involve organic materials that could degrade. Most participants (N = 5) stated that samples used for scent imprinting were stored in freezers. Other participants used a 'dehydrator to ensure that it did not mould' (S4) and did not state whether freezing was used as a method. Others used various airtight and waterproof containers such as 'zip lock bags' (S1; S7), 'mylar bags' and 'nylofume' (S2), or 'glass jars' (S3).

The gathering of samples usually took place during other projects whenever opportunities arose: 'Sample collection was opportunistic and easily done thanks to other work' (S1).

T1.2. Use of Discrimination Trials

Discrimination trials, as described in the Introduction, are used to test whether the CDD is indicating on the correct odour in a lab-based setting before progression to the field. Whether or not discrimination trials were used by participants varied, with more than half of participants (N = 4) using them and the rest (N = 3) opting not to. Those that used discrimination trials focused on using scents commonly used during training, such as 'clean zip lock bags, clean swabs… gloves' (S7), and in the field environment, like the scent or faecal matter of other animals commonly present alongside the target species. A justification for using discrimination trials was the vast array of distracting scents the CDD would face in the field and a need to prepare them for this: 'The island has a population of 92,000 Atlantic Puffins *Fratercula arctica* and many more of sea birds [*sic*], during the seabird breeding session. Also, a large rabbit colony' (S3). Reasons for deciding not to conduct discrimination trials included having a broad range of target species for a project and wanting to avoid degrading 'communication, trust, and understanding between the dog and handler' (S4) by not rewarding due to incorrect indications on the distractors.

Question: Did you perform discrimination trials, if so, what did you use as distractor scents and what was the outcome of these trials?
We used a lots of different bird feathers, collect from the island, of many species but mainly Puffins. We also used rabbit droppings as a distractor odour.

(S3)

Question: Did you perform discrimination trials, if so, what did you use as distractor scents and what was the outcome of these trials?
The dog proved capable of ignoring Ancient Murrelet [Synthliboramphus antiquus] burrows and carcasses.

(S1)

> Question: Did you perform discrimination trials, if so, what did you use as distractor scents and what was the outcome of these trials?
> *We do not perform these trials… We do everything we can to naturally add distractor scents when we are teaching the dogs odours (and by this we mean we set out samples in areas with deer, coyote, turkey, etc., naturally occurring on the landscape).*

(S4)

T1.3. Imprinting scent samples

The types of materials that were used to imprint CDDs onto seabird species odour was dependent on when the imprinting took place. For practicality, pre-field training work involved the use of whole carcasses, body parts like wings and feathers, associated items such as 'cloths used to handle Wedge-tailed Shearwaters' (S6), and 'swabs of birds' (S7). When in the field, visits to active next sites and live birds caught for alternative purposes such as banding were also used for further imprinting. Any caught live birds were contained by the individuals performing the alternative purposes, not the CDDHT. The purpose of continuing imprinting once operational and present in the field was to 'fast track learning… before going to areas with unknown or lesser activity' (S4), especially given the 'slow and uphill battle to obtain the appropriate materials' necessary for training (S4). Furthermore, it was stated that imprinting should involve samples from multiple individuals of a species with, 'as large a number of the target species as possible to create a common odour profile' (S3).

> Question: How did you imprint the dog and on what?
> *First imprinted the dog on feathers, then Manx Shearwater wings, then swabs of birds that were caught during ringing operations.*

(S7)

> Question: Were there any welfare concerns for the target species that you took into account?
> *[The dog] and I could stay near the site and every half hour or so, go back to reward. I felt the repetition was helpful.*

(S4)

T1.4. Indications of potential targets

Indication refers to the way in which CDDs alert their handlers of a potential target. The specific style of indication employed by CDDs was determined by the training they receive from their handlers. All respondents that provided information on indications (N = 5) used passive indication (i.e. no interaction with the target) in forms such as 'sit and stare' (S7), 'laying on the ground' (S6), 'freez[ing]' (S3), and 'look[ing] back (S2). The primary reason given for using this method was to reduce disturbance and risk of distress for live birds. However, one respondent stated that they found that 'sometimes the dog sits because it is tired and it can be a bit confusing (S5)', and suggested that a passive indication accompanied by an auditory cue such as 'barking' could help in such cases or if the CDD is out of sight when they find a nest.

> Question: Is there anything else you think would be important for a scientist taking on a dog team, or a dog team beginning work on a seabird project to know?
> *The use of a professional dog team that have a solid passive indication.*
>
> (S7)

> Question: Was there any particular training you gave the dog for this project?
> *We will train dogs not to nose poke the target.*
>
> (S2)

T1.5. Rewarding CDDs during an operational search

The style of rewarding varied depending on how visually confirmable the target was. If the target was able to be immediately confirmed by the handler, then rewards were given 'right away' (S6). In more than half of cases (N = 4) when the target was not confirmable, handlers would reward partially through praise, take the dog away, verify the find, and then either bring the CDD back in for a find followed by a 'full reward' (S7) or take the CDD to a site planted with target scent to still achieve a reward. Unconfirmable targets may have been due to high vegetation or needing time and specific equipment like 'endoscope[s]' (S7) or 'cameras' (S6) to verify a burrow site. However, one respondent stated that they 'would not reward' an indication from the CDD unless they could confirm that the find 'was very likely to be a nest' (S5). It should be noted that this theme contained the most variation between respondents regarding how exactly they handled rewarding the CDD. In some cases, it was unclear what type of reward the CDD received before and after a find was verified (i.e. praise, food, play, etc.).

> Question: Is there any particular training you would focus on if running the project again?
> *Variable reward system, so the dog is rewarded at known finds, but is happy to be moved on from a find without a full reward.*
>
> (S7)

> Question: When the dog was on an operational search how did you check if the dog indicated correctly, did you reward right away or did you check then send the dog back in to reward?
> *We would only reward the dog after verifying what was indicated was very likely to be a nest. Otherwise, we would not reward it.*
>
> (S5)

T1.6. Methods of on-site training

More than half of respondents (N = 4) advocated for the use of field trials as a form of on-site training (i.e. running searches on-site with the CDD that either involve planted finds such as 'Storm-petrel feathers in empty burrows' (S1), or real finds such as 'active burrows' (S1). Conducting field trials allowed the CDD to learn the odour profile of an operational find rather than just that of training materials. In this way they a CDD could learn to detect nests rather than just 'a single feather hidden in the field' (S5).

To run field trials efficiently and make the best use of the limited time on-site, 'pre-planning' (S4) via the mapping out known burrows or placing samples in advance, was recommended prior to arriving in the field with the CDD. One respondent felt that field trials involving placed samples were not 'representative of actual fieldwork' (S4) and so instead opted for repeatedly reinforcing the CDD on confirmed nests and live specimens whilst on-site.

An additional factor to consider as part of on-site training is the effect of the field location on training outcomes. In cases where Storm-petrels were the target species, islands where these birds live 'smelled very strong[ly] of Storm-petrel oil' (S4) which meant the CDD may have needed more time to differentiate the target odour profile from other powerful scents on-site.

> Question: Did you perform field trials before making the dog operational, if so how was this done?
> *Yes, we plan to do a series of field trials. We plan to design the trials in collaboration with biologists and researchers who have conducted human/visual survey trials for the same purpose ([finding] downed seabirds).*
>
> (S2)

> Question: Is there anything else you think would be important for a scientist taking on a dog team, or a dog team beginning work on a seabird project to know?
> *[We] have burrows already mapped out in high activity or known areas for dogs [to search].*
>
> (S4)

Theme 2. Location

The location of the operational search played a key role in how a search was conducted as well as the outcomes and difficulties faced during a project. Though all respondents were part of CDD seabird projects and as such were working on islands, the types of location surveyed during each project varied greatly. Some locations had a lot of vegetation and were 'heavily treed' (S1), covered in 'grass banks' (S3), or consisted of 'open understory… heavy (mature) old growth overstory… [or] dense understory' (S4). Others were at great elevations above sea level and had terrain consisting of 'extremely rough pahoehoe and a'a lava' (types of lava formations) (S6) or 'mountainous rocky areas with some soil, sometimes with difficult access for people' (S5). In particular, cliffs were a common obstacle faced by CDDHTs regarding access and safety.

Question: Where was the search site and can you describe the area?
On islands around the coast of Ireland.

(S7)

Question: Where was the search site and can you describe the area?
Isle of May nature reserve. We were given an area to search proximally 3 acres in size, mainly grass banks but with large rocky outcrop and gullies.

(S3)

Question: Would you have done anything differently if you do the project again?
Dense Storm-petrel colonies are difficult areas to work with the dog.

(S1)

T2.1. Effects of location on search methodology

The terrain and layout of the project location dictated how the CDDHT approached the search. Regarding the use of a leash, respondents (N = 3) stated that CDDs would search on a leash (or 'line') due to considerations of the welfare of wildlife in the area. For example, leashes were used 'to ensure they (the CDD) don't disturb any live potentially injured seabirds' (S2) or for the safety of the CDDHT: '[the] dog searched on long line due to cliffs (S7)'. In addition, off-leash searches were also conducted (N = 2) either because of topography that was 'not conducive to using a leash' (S2), or if the CDD was trained to work in close proximity to the handler at all times to 'minimize both of our impacts around and near the burrows' (S4). Furthermore, specific search techniques may be needed or adapted for use due to the field location. For example, CDDHTs might either 'search burrows' (S7), or use 'transit [transect] line searches all on lead' (S3) or have to change from using transect lines to conducting free (i.e., non-leashed) searches 'due to the terrain of the island' and it not 'always [being] possible to run the line' (S3).

Question: Would you have done anything differently if you do the project again?
We had trained the dogs to run transit [transect] lines, but due to the terrain of the island it wasn't always possible to run the lines, so [we] had to free search the dogs on long lines. More training of this would have been beneficial.

(S3)

Question: What search style and indication did the dog have?
The areas we were working in were fragile, so [the dog] and I worked closely together.

(S4)

T2.2. Challenging conditions

Most respondents (N = 6) encountered a variety of challenging conditions during their projects because of needing to travel to the project site or the field location. For example, given that seabird projects tend to take place on islands, boats are regularly involved. Specific training on boat travel for CDDs may therefore be necessary: 'we trained getting off and on boats… walking on metal grids and being lifted' (S7). Furthermore, weather conditions that affect the ability to sail can impede progress: 'we lost one day to inclement sea weather… [we were also] limited by tides and weather to access different islands' (S4). In general, transport was difficult due to the often-remote nature of the search sites, with sites often being 'arduous to get to' (S6), or it being 'necessary to walk for one to three hours to arrive' (S5). Another respondent stated that 'none of the islands had a dock' (S4).

The location, terrain and conditions encountered during projects can cause concern for CDDHT safety: 'some sites were a bit dangerous for the dog working very close to cliffs, slippery areas, rocky areas with high jumps, etc.' (S5). Other projects involved 'working in heat' (S7), whilst others required protective equipment such as specialised dog boots (S6). In one case, a CDD 'injured its paw at the boat launch' (S1) which limited its working abilities. One respondent called for the need to 'plan on more time' (S4) to combat challenges that may arise.

> Question: Were there any welfare issues for the dog on the site or health and safety issues you had to take into account working on that site?
> *Dog cracked a nail on day 1. [This] limited the number and length of days it could train and work and increased the frequency of breaks.'*
>
> (S1)

> Question: How was the communication between dog team and ecologist?
> *It was sometimes hard to organise days to go out to site that suited both [the CDDHT and the ecologist] and worked with tides.*
>
> (S7)

> Question: Would there be anything you will make sure to communicate promptly if a project goes forward again?
> *Understanding that we would need more time on-site in hotspots before deploying a team to conduct actual surveys.*
>
> (S4)

Theme 3. The role of handler

The role of CDD handler within the CDDHT and what this entails was discussed by more than half of respondents (N = 4). First and foremost, the handler acts as a caretaker for the CDD through its training. They 'continue the training out of the working periods' (S5) and advocate for their needs, such as if 'the dog needs breaks' (S7). The handler is often an ambassador for the CDD method, explaining to other staff that work on seabird projects (such as ecologists) how it works and why variation occurs. One respondent said 'it often feels like I am trying to convince project players that the method works whenever a hiccup or a challenge occurs' (S4). Being a handler can also involve taking time to learn from other handlers from the global community, rather than making similar mistakes to those made in previous projects. To learn more about the role, a respondent suggested that handlers 'speak with multiple programs/detection teams prior to selecting an operation, to learn whether the method is one they are willing to pursue and with all the various caveats' (S4). This networking amongst CDDHT was cited as being able to 'strengthen the methods and ensure a stronger community of detection teams overall' (S4).

> Question: How was the communication between dog team and ecologist?
> *[We] learned from each other about ecological factors and the dog nuances.*
>
> (S6)

> Question: Is there anything else you think would be important for a scientist taking on a dog team, or a dog team beginning work on a seabird project to know?
> *Continuously changing the person in charge of the dog … is not good for the dog or for the efficiency of the work.*
>
> (S5)

> Question: How did you select the dog or dog team you were working with?
> *As we are always ambassadors for the method, we felt bringing one of our most established canine team members with us would provide confidence in the methodology.*
>
> (S4)

Theme 4. Considerations of local wildlife

The welfare of the target species, as well as other wildlife that live in and around search sites, was considered by all respondents (N = 7). Several precautions were taken to ensure that distress to wildlife by CDDs was minimal, including using a 'leash whenever possible', putting 'muzzles on all dogs', and 'taking dog away immediately' following a search (S2). Other precautions included searches being 'carried out after the main seabird-breeding season to ensure there were not many birds around' (S3), using 'passive indication' (S7), or 'decid[ing that] the dog [would] not bark when it found a nest' (S5). The prey drive, how motivated they are to hunt other animals, of the CDD was also considered, although CDDs are usually 'trained not to touch/harm/go near any birds in the areas' (S6). One respondent noted that 'dog behaviours are not 100% predictable' (S2), and that safety procedures are therefore necessary.

> Question: Were there any welfare concerns for the target species that you took into account?
> *The live birds that will be found may be injured, stressed or confused already, so we will make sure that contact with the bird is minimal.*
>
> (S2)

> Question: What search style and indication did the dog have?

The dog searched on long line due to cliffs and requests by scientists on project to protect the birds.

(S7)

Question: Were there any welfare concerns for non-target species that you took into account?
Avoiding the dog… pursu[ing] other domestic animals.

(S5)

Theme 5. Dog selection criteria

There are several elements that were considered by all respondents (N = 7) regarding how a dog was chosen to perform as the CDD for a project by CDD handlers and potentially project stakeholders. Regarding the dog itself, some respondents (N = 3) stated that personality traits such as a 'medium to high level of working drive' and 'zero prey drive towards birds' (S2) were important. Certain physical attributes may also be needed for specific tasks: 'since Cabo Verde is a hot country I would have chosen a dog with short hair [and a] medium sized dog (rather than a big dog) to be able to take small flights' (S5). Although the physical and behavioural characteristics of the dog are important, most respondents (N = 6) chose experience and reputation as the most vital factors in choosing a CDD for their respective seabird project. Dogs were chosen based on references and 'word of mouth' (S6) from other professional handlers and projects, and due to the level of experience they had in detection work: 'we felt it was important to select a well-experienced team' (S4); '[we required] past detection experience' (S2).

Question: How did you select the dog or dog team you were working with?
[The dog had a] good reputation with colleagues from other projects and had worked in the study area previously.

(S1)

Question: How did you select the dog or dog team you were working with?
[I chose] my most experienced dog; [they are] the quickest to imprint on a new odour.

(S7)

Question: How did you select the dog or dog team you were working with?
[The dog] and I have worked together on countless projects over numerous years, and I knew I could count on him to be sensitive… We did not feel comfortable sending less experienced teams due to the complexities and sensitivities of the project.

(S4)

Discussion

This study aimed to investigate how professionals who work on CDD seabird projects conduct their studies and handle their CDD to inform best practice in the field. It was found that the most vital aspects to be considered when using a CDD are: (1) the techniques and approaches used during training ($N_{respondents}$ = 7), (2) how the location of a project affects its management and outcomes (N = 7), (3) the role of the handler in caring for the CDD and advocating for the method (N = 4), (4) protecting wildlife during a project (N = 7), and (5) what characteristics a CDD should have when working with seabirds (N = 7). These findings highlight how both the preparation and the execution of a project are important and that micro-level influences, e.g. the dog and the handler, as well as macro-level, e.g. the project location and collaboration between stakeholders, all play a role in a CDD project and its outcomes. Considering these findings, the authors of this study summarise best practice recommendations for the use of CDD in seabird projects (see Table 3).

Table 3. Best practice recommendations for conservation detection dog use in a seabird projects.

Themes and sub-themes	Recommendations
T1. Training	Research all conditions that may be faced while travelling and on-site to prepare the dog as best as possible.
T1.1. Scent sample storage	Ensure sample contamination is kept to a minimum via the use of appropriate storage techniques like freezing, airtight containers or dehydration. Where possible, network and use other ongoing research projects to obtain scent samples.
T1.2. Use of discrimination trials	Based on the subjectivity of the use of discrimination trials, whether to use them may depend on three factors: (1) the handler's assessment of the CDD's personality and thus their ability to handle this aspect of training, (2) whether the dog is looking for more than one species, (3) the risk of confusing communication between the handler and the dog.
T1.3. Imprinting	Both organic materials (e.g. feathers, body parts, scat, etc.) and swabs from specimens can be useful for imprinting, when stored correctly. The fresher and more relevant the scent sample is (i.e. whether it is from a specimen that lives where the project will take place), the better the outcomes of imprinting.
T1.4. Indication	Passive indication (i.e. no contact with the target) is key. Common styles include pointing, sit and stare and lying down.
T1.5. Rewarding	Full rewards should generally take place once a target has been confirmed by a handler. Partial rewards (e.g. verbal praise) may be used in the interim. Training the dog to accept variable reward schedules is important to avoid their frustration.

T1.6. On-site training	Field trials are useful for acclimatising the CDD to the project location and true odour profile. Pre-plan for field trials (i.e. already having targets laid out or marked prior to CDDHT arrival) to save time on-site.
T2. Location	Prepare for potential high variability in terrain, vegetation, weather, and transport that can occur during field work.
T2.1. Effects on search methodology	Experience in differing search techniques (i.e. free versus transect, line versus off leash) means all contingencies are accounted for. If needed, train for specific searching abilities (e.g. burrows, thick undergrowth).
T2.2. Challenging conditions	Include extra time within the project timeline for unpredictable conditions.
T3. Role of handler	Understand the pros and cons of the CDD method so that any questions or concerns from stakeholders can be addressed. Reach out and network with other CDD handlers as much as possible, especially given the diversity and worldwide nature of the field.
T4. Wildlife considerations	Use protective equipment (e.g. leashes and muzzles) when working near other animals. Reducing or limiting interaction time between CDD and wildlife as well as the ability to read canine behaviour accurately can prevent mistakes or accidents.
T5. Dog selection criteria	Dogs should be selected based on the project needs and conditions, including but not limited to temperature, transport and sensitivity of project site. Experience and reputation are the highest rated indicators of a well-performing CDD.

Given the importance of specific training and environmental experiences for enhancing the capabilities of working dogs (Lazarowski *et al.* 2021), it is unsurprising that training emerged as the theme with the most subordinate themes, including imprinting which is considered the basis of CDD work (Mosconi *et al.* 2017). However, there is variation in how CDD professionals undertake training with differing rationale for why certain techniques are or are not used, particularly discrimination and field trials. The recommendations made by this study emphasise the importance of making decisions on the use of certain methods based on the individual dog and the structure of the project. Moreover, future research into the benefits and deficits of these techniques, with aims of establishing when they are best used, would be useful for standardisation.

The role of the handler theme is particularly pertinent given the nature of CDD work and the importance of collaboration in science. Indeed, a recent publication by Richards *et al*. (2021) discusses the vital role the handler plays as part of a CDDHT. Although volunteer handlers can and have been used in conservation scent detection (Rutter *et al.* 2021b, 2021a), many ecological projects hire a professional CDDHT to conduct the detection work and thus involve the merging of disciplines. Interdisciplinary projects and collaborations in research can result in higher-impact studies (Wuchty *et al.* 2007), and so, as discussed by the participants, handlers must advocate and explain the CDD method to those who are unfamiliar with it within these contexts. However, discussions on this aspect of being a CDD handler are scarce in the literature. Furthermore, the likelihood of collaboration in research is reduced by increasing geographical distance (Parreira *et al.* 2017), a factor likely to impact CDD research given the global nature of the field.

There are several strengths and limitations to be considered in this study. Participants came from a wide range of countries and organisations, including projects involving both seabird and invasive species detection, and there was a good balance between handlers and ecologists which allowed for a broad perspective. Furthermore, most of the research conducted was unpublished which means there is now an opportunity to learn from, and appreciate the value of, the work conducted. However, not all eligible participants may have been reached based on the recruitment strategy that was used, which limited the geographic coverage of the study. For example, there were no respondents from New Zealand, credited with having the first conservation detection dog looking for New Zealand Kiwi (*Apteryx* sp.) in the 1890s, and where there is a government run conservation detection dog program (Beebe *et al.* 2016). Additionally, although responses to the structured written nature of the survey provided a great deal of information, it is possible that more data could have been gathered from a semi-structured verbal survey where longer answers or follow-up questions may have occurred.

This study has highlighted considerations relevant to those seeking to contract a CDDHT for seabird surveys. Such considerations include the benefit of contacting a team as early as possible in the survey design stage to allow enough time for training and scent sample collection. We also provide some guidance as to what information CDDHTs need to know (in terms of terrain, other wildlife, and transport limitations) to carry out a survey most effectively.

In conclusion, this study shows that there are many elements to consider when designing and implementing a CDD seabird study. Some of the emergent themes, like training and selection of a dog, are established in the literature. However, highlighting aspects such as the influence of highly variable conditions and the role of the handler outside of CDD care, which are less discussed, demonstrates the immense value of gathering knowledge of those with experience. In a field where standardisation is limited and methods can differ from project to project, it is hoped that the recommendations put forward here will act as one of the first steps in establishing a standard for how to use CDD effectively as part of seabird conservation projects and beyond.

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Appendix 1

Survey questionnaire sent to participants.

Thank you very much for agreeing to take part in this questionnaire. The answers you give will be anonymised and used to create a short communication outlining the basic thought processes needed before a detection dog team is brought into a seabird project. This questionnaire has been sent to both scientists and detection dog handlers/trainers involved in seabird projects so some questions may not be relevant to you, please leave them blank. If there are any questions you do not want to answer or can't answer currently please leave them blank. Any additional comments you think are important please add them at the end of the questionnaire. If there are any questions you would like clarity on please feel free to get in touch at caroline@cddni.com and send your completed questionnaire to this email also.

Introduction to project

What was the project called?

Who were the project partners and what was your job on the project?

What was the aim of the project?

What was the aim of using a dog on the project if different from the overall project aim?

Dog selection

How did you select the dog or dog team you were working with?

Was there anything you would have preferred that dog or dog team to have or be able to do?

Imprinting odour

What species was the target odour?

How did you imprint the dog and on what?

Who gathered the samples used to imprint the dog?

How easy was it to get samples to imprint on and how did you store them for longevity?

Would you have done anything differently if you do the project again?

Did you perform discrimination trials, if so, what did you use as distractor scents and what was the outcome of these trials?

Search style and operational searches

What search style and indication did the dog have?

Was there any particular training you gave the dog for this project?

Is there any particular training you would focus on if running the project again?

Did you perform field trials before making the dog operational, if so how was this done?

When the dog was on an operational search how did you check if the dog indicated correctly, did you reward right away or did you check then send the dog back in to reward?

Search site

Where was the search site and can you describe the area?

Was there transport issues to site or issues once on site?

How long would you be on site for?

Were there any welfare issues for the dog on the site or health and safety issues you had to take into account working on that site?

Communication between scientist and dog team

How was the communication between dog team and ecologist?

Was there anything you wish you had known before the searches began or being on site?

Would there be anything you will make sure to communicate promptly if a project goes forward again?

Welfare concerns external to the team

Were there any welfare concerns for the target species that you took into account?

Were there any welfare concerns for non-target species that you took into account?

Any other comments

Is there anything else you think would be important for a scientist taking on a dog team, or a dog team beginning work on a seabird project to know?