Biodiversity and Conservation Science

Humpback whale photo-identification catalogue review 2019

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1 Background

In 2016 a trial of the in-water interaction with humpback whales tourism industry was initiated at Ningaloo Marine Park (NMP), Western Australia. The trial, now in its fourth year, is likely to transition to a permanent industry by 2021 managed by the Department of Biodiversity, Conservation and Attractions (DBCA). The success of the initiative relies on the development of an effective management framework to minimise impacts on whales and risks to swimmers. In turn the success of the management framework will rely on being informed by a sound and strategic monitoring and research programme. The programme has the aspiration to develop best practise standards similar to the well-established whale shark tourism industry at NMP.

A research and monitoring plan has been in place during the trial to assess:

- humpback whale abundance and distribution, including establishing monitoring protocols to detect change to this condition over the long term;
- short-term impact(s) from the direct activity on whale condition (i.e. changes in behaviour or distribution, signs of disturbance or avoidance); and
- The effectiveness and suitability of the management of the activity in relation to swimmer safety and visitor satisfaction.

Photo-identification (photo-ID) of individual whales is one technique that can be used to better understand individual life history, movement patterns and population demographics. This tool relies on capturing high quality photos of individual whales with enough detail of particular features that can be used to recognize individuals over time when they are photographed or sighted on multiple occasions. The photographs can be used to create a catalogue of recognisable individuals with which to compare future photographs. The dataset that is associated with the catalogue includes information on the date and location of each sighting of an individual and can also include details such as presence and identify of conspecifics, reproductive status and activity. Such a dataset can be used over time to examine questions on population demographics (e.g. reproductive status and interbirth intervals), distribution and movement patterns, social behaviour as well as to estimate abundance using mark-recapture modelling.

For humpback whales, features used for identification include the dorsal fin (distinguishable by shape, nicks and marks) and underside of the flukes (distinguishable by pigmentation pattern and trailing edge of the flukes). Photo-ID can be used to create sighting histories of individual whales within and between years to better understand their migration patterns, important habitats, site fidelity and residency. For photo-ID to have long term benefits and be applied to management questions requires proper data management including processing of photographs and construction and maintenance of a catalogue that contains records of individual whales and their resighting history.

In 2017 Batemans Bay in NMP was identified as an emerging high use area for humpback whale mothers and calves, highlighting our limited understanding of the expanding humpback whale population and consequent expansion of breeding, nursery and staging areas during the annual migration. This prompted research to better understand whale residency patterns and use of Bateman Bay to determine whether this site should be considered a nursery or staging area. Regular boat based surveys of Bateman Bay were undertaken during the 2018 humpback whale migration season which included running a survey of pre-determined transects throughout the Bay, recording each whale/group sighted and collecting photo-ID data during these surveys, i.e. photographs of individual whales encountered along with information on group composition, location and activity. The photographs were processed manually to identify individual whales that could be recognised by their features. A basic catalogue was created in Microsoft Powerpoint to assist in processing new photos from later surveys and either matching whales to recognised individuals or adding new individuals throughout the season. The photo-ID dataset for the Bateman Bay project therefore comprised the number and identity of unique individual whales photographed during the surveys and information on when and where they were sighted, including repeated sightings on the same or multiple days. This information was used to better understand the length of time individual whales were using Bateman Bay.

While there are no plans for the expansion or curation of this catalogue and associated data as the project was proposed for a single year, such a catalogue would support the long term collection of data on humpback whales that use NMP and could be used to explore management questions on temporal and spatial use by the whales of NMP and population demographics including reproductive status and inter-birthing intervals. In addition, the catalogue would support long-term monitoring of the humpback whales, estimating pressure on whales from tourism and help identify individuals, cohorts or areas in NMP that might be more vulnerable to the impacts from tourism. Further, linking photo-ID data to data collected by tour operators through their electronic monitoring system (EMS) may improve our understanding of the industry and its potential impacts over the long term as occurs with whale sharks, particularly where tour operators can provide their own photographs of whales taken during interactions.

Examples of potential questions that could be answered to support and inform management using long-term photo-ID and survey data of humpback whales include:

- How do humpback whales use NMP, i.e. what activities are they engaged in e.g. resting, travelling, calving/nursing etc?
- What are important locations within NMP where these activities are undertaken, and are they used for extended periods of time within a season or only briefly?

- What is the residency time of individual whales within a season using NMP?
- Do individual whales using NMP only use a selected location, or do they consistently move around within the park?
- Do individual whales return to NMP and the same places within it regularly and, if so, what is the interval between visits?
- What are some of the life history parameters of humpback whales using NMP e.g. calving intervals, age at sexual maturity, etc?
- What are the key areas for calving identified from the presence of neonates during photo-ID surveys and what are some of the age and sex demographics of the whales visiting Ningaloo, i.e. are they mainly mothers with young calves?
- Is there repeated interaction with individual whales with commercial tour operators? Does the behaviour of whales and the way they use NMP influence the probability of repeated interactions?
- How do the number and length of interactions with commercial tour operators vary within and between seasons and is this influenced by the number of times an individual whale has been encountered or the length of previous interactions?

Given that we have only just begun to collect this type of information on humpback whales as part of the research and monitoring plan associated with the humpback whale in-water interaction tourism industry, it is an opportune time to review photo processing and database systems currently available to manage photo-ID catalogue information. The technology has evolved quickly in the last few decades with the addition of artificial intelligence and algorithms that can be used to partially automate the matching process of resighting whales using their individual marks.

DBCA Exmouth District do not currently have any dedicated resources to devote to the collation and storage of the humpback whale photo-ID photos and data, thus alternative and cost-effective options need to be explored. The collection of photos for photo-ID of whale sharks and management of data provides an effective model to consider for humpback whales. Currently the process for whale sharks involves tour operators providing their photo-ID photos to DBCA for collation. DBCA then provides the photos as a resource to researchers and photo-ID platforms on request, and free of charge, for appropriate purposes. One such platform used for whale shark photo-ID is Wildbook which is a very open and collaborative platform for storing, managing, curating, and analysing data and has been tailored towards citizen science, providing the public with a high level of access to all data as well as direct feedback to data contributors when the individual whale sharks they have photographed and submitted are resighted.

The aim of the following review is to assess the advantages and constraints of current humpback whale photo-ID catalogues and data management systems including the types of management-related information that each can provide. Recommendations are made on a cost effective and user-friendly catalogue that would suit the long-term needs of the Department, particularly the Exmouth District,

in relation to the in-water interaction with humpback whale industry. This includes specific advice on the resources required to build and maintain the catalogue along with advice on the management questions for which the associated data could be used.

2 Methods/Process

We met with current users and developers of photo-ID catalogues for whales and used a desktop assessment approach to gain an understanding of the current systems available, their accessibility and ease of use.

The experts we contacted were:

- Associate Professor Chandra Salgado-Kent (ECU/Oceans Blueprint) https://www.ecu.edu.au/schools/science/staff/profiles/associate-professors/associate-professor
- Dr Daniel Burns (Adjunct fellow Southern Cross University/Blue Planet Marine) https://www.scu.edu.au/about/contacts/staff-directory/staff/35855.php https://blueplanetmarine.com/about
- Mr Andrew Davenport (Database manager for Centre for Whale Research) http://www.cwr.org.au/about-us/2-3-the-cwr-team.html
- Mr Jason Holmberg (Information Architect of Wildme and Wildbook) https://www.wildme.org/contact/

From these discussions and our own trials of the catalogues it was established that there are essentially 2 ‘types’ of photo-ID catalogues available 1) basic photo editing software with the ability to tag, catalogue and edit photos within software(e.g. Adobe Lightroom Classic CC, Daminion, ACDSee). Photos are manually and individually processed and matched with other photos in the catalogue, including naming of new individuals and tagging photos with useful key words. A separate spreadsheet is needed to compile information on individual sighting history. 2) relational databases that can accommodate survey and sightings data as well as associated photos and collate sighting histories of individuals in a catalogue over time (e.g. Flukebook, Flukematcher and CWR (Filemaker pro custom made database)). While photos need to be individually processed and matched with the catalogue, the information on sighting and survey is entered with the photo into a relational database that can be queried. Some of the latter systems (i.e. Flukebook and Flukematcher) have the additional feature of using algorithms to semi-automate the matching (resighting) process by ranking potential matches that then must be validated by a user.

3 Results

Following are descriptions of available data management systems/applications for cataloguing photo-ID photos and information broken down into photo processing

software and data storage systems that include photo matching software and relational databases.

Photo processing software

Adobe Lightroom Classic CC

Lightroom is a photo editing application that expands on the well-known and traditional Adobe photoshop desktop application. Adobe Lightroom allows importing/saving, viewing, organizing, tagging, editing, and sharing large numbers of digital photos. Individual photos can be tagged with any desired information such as the identity of the individual in the photo, classifiers (such as used in CWR and Whale Tale), photo quality, species, group number and composition, and when and where photographs were taken. This requires people to learn the software if they don't already know it, and strict protocols to ensure they input the tag information consistently and in the same order for each photo. The photos are organised by the user into folders e.g. corresponding to years and/or locations. These folders are easily navigable within the interface. The photos in these folders can then be queried and filtered on relevant tags and displayed together. The photos are arranged along the bottom of the window, and are selected and matched one at a time, with the metadata (tag data) input by the user. A maximum of two photos at a time can be displayed side by side for matching i.e. the new photo and an existing catalogued photo. Lightroom is not customised for matching, for example there is no arrow to click and advance through the photos. Nevertheless, software allows the full range of photo editing capability to adjust such things as exposure, contrast, sharpness, etc. All metadata can be exported as a .csv file for analysis. Other users have gone a step further and linked to excel spreadsheets with macros to further organize their data for analysis and reporting. An example includes Plugin LR transporter or customized excel file with macros to 'mine' metadata from photos to create sighting histories. However, while Lightroom software manages large amounts of high-resolution files, it is not a relational database and thus lacks the capacity to store large volumes of sighting or survey information. Lightroom also lacks a 'semi-automated' matching routine. However, by including classification tags the number of comparisons that need to be made to find a match can be reduced. Lightroom can be accessed here https://www.adobe.com/au/products/photoshop-lightroom-classic.html including for a trial period. There is a licence cost associated with Lightroom given it is proprietary software.

ACDSee

ACDSee is a photo organizer, viewer, and photo editing software program and proprietary ACD Systems International Inc. This software was developed many years ago and continues to be updated with new iterations. It is very similar in its functionality to Adobe Lightroom Classic CC. The main difference between the two programs is the memory required to run them i.e. Lightroom uses significantly more computer memory than ACDSee however ACDSee uses more computer processing

requirements (Central Processing Unit) than Lightroom. ACDSee can be accessed here https://www.acdsee.com/en/products/install?prod=acdsee-photo-studio-ultimate-2019&v=12.1.0.1656&o=win1000&ar=64&l=en&pid=ACUW12EN&d=0 including for a trial period. There is a licence cost associated with ACDSee given it is proprietary software.

Daminion

Daminion is a freeware photo editing software program that also allows organizing of photos in a catalogue. It is most similar to Adobe Lightroom Class CC in its capability and functionality although the interface may not appear as polished as the proprietary software. This is an accessible and free alternative to the licensed software (ACDSee and Lightroom). The software https://daminion.net/download-server?showbuttons and a personalised tutorial can be scheduled here https://daminion.net/home/schedule-a-demo.

Data storage systems

Flukebook

Flukebook is a free on-line system that enables researchers to manage, share, analyse and archive marine mammal photo-ID data. It was originally designed to manage tail fluke photos but is being expanded to also accommodate dorsal fin photos. Flukebook uses a combination of photographs of flukes, dorsal fins, and scars to distinguish between individual whales. The system enables rapid identification using pattern recognition and photo management technology. It includes a relational database that stores the photos and sighting/resighting information for each individual whale identified.

Contributors retain full ownership and control access to their data in Flukebook. Permission settings control access to data and allow for easy collaboration between groups. Flukebook can be used within organizations to allow web-based access to data but permissions can be changed to facilitate collaboration with external researchers or other stakeholders (e.g. commercial tour operators (CTOs)). The application is web-based which means team members, in multiple locations, on multiple computers can all work on the same dataset, including adding new photos, identifying new individuals and resights of existing individuals, at the same time.

Flukebook can automatically detect the fluke within the photo frame, analyse the photo and match it using three different algorithms (Curvrank, Hotspotter and Dynamic Time Warping). This function is being extended to include dorsal fins which requires the adaptation of the Curvrank algorithm that is applied to trailing edges of other taxa *e.g.* bottlenose dolphin dorsal fins and humpback whale flukes and will be adapted and trained for humpback whale dorsal fins. The automated matching process may be improved if photos are pre-edited before being uploaded into Flukebook. The running time of the algorithm for matching depends on the number of images being compared, however it takes approximately 3 minutes (hundreds of

images) to display the top 10 ranked photos against a new photo. A longer run can be used for matching larger datasets i.e. overnight if needed. Associated sighting information included in the database, allows for the creation of sighting histories for individual whales. The sighting histories can then be exported for analysis and reporting in different formats. Summary files of sighting histories can be exported in multiple formats including kml (google earth compatible) shapefiles and excel files. These can then be used for population analyses in program MARK or social analyses in program SOCPROG. Questions to support management that could be answered include within and between season resightings of individuals.

Flukebook is freely available https://www.flukebook.org/overview.jsp and there are several useful tutorials i.e. search and export with Flukebook: https://www.youtube.com/watch?v=EYylAOAzX50 computer vision with Flukebook: https://www.youtube.com/watch?v=3_QQrJ5lCxg&t=27s

http://www.cascadiaresearch.org/publications/testing-two-new-automated-fluke-identification-algorithms-and-comparison-non-automated

Fluke Matcher

Fluke Matcher is a computer-aided matching system for humpback whale fluke photos (cannot accommodate dorsal fins), developed over 10 years ago by Dan Burns and Eric Kniest. It was written in FORTRAN (approx. 10000 lines of code) and is Windows PC compatible, not suited to Macintosh operating systems (but can be used on Macs via virtual desktop programs such as Parallels or VMWare). It consists of two modules 1) measurement module – where the user inputs the new fluke photos with a user-friendly graphical interface, and 2) search module – where the program attempts to match a fluke with the existing fluke photos in the database. The search module requires the user to mark reference points (known as control points) that are used to search the existing dataset of flukes. The system was successfully tested on a verified dataset of 860 humpback whale flukes as part of Daniel Burns PhD project (Kniest et al. 2010). The maximum capacity of photos for the database is 5000. Photos should be processed in appropriate editing software prior to importing into the database. The photo resolution is only limited by the screen resolution of the monitor that the matching is being done on. The photo grading score (SPLASH categories: proportion visible, fluke angle, lateral angle, contrast and focus) is automatically assigned and these can be changed manually and used to filter. The algorithm ranks the photos from most likely to least likely and then the user visually checks and confirms. Once a match is made associated data on the sighting can be entered. Where no match is made, a new individual can be entered into the catalogue, with associated sighting information. Photos must be uploaded individually and this takes 4-6 minutes per photo but the matching algorithm takes approximately 30 seconds to compare 100 photos. The most extensive test of the system showed 91% of a possible 1314 matches listed in the top 10% of the ranked images, and 96% listed in the top 20%. 5 matches (0.4%) ranked in the bottom 50% of the database. Sighting histories can be exported as csv files but require editing for use in MARK and other population analysis programs. More detail is available in the peer-reviewed publication

https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1748-7692.2009.00368.x and Burns (2010) PhD thesis: https://epubs.scu.edu.au/theses/273/

Centre for Whale Research Filemaker Pro

The Centre for Whale Research (CWR) uses a customized database to manage their data in the software Filemaker Pro. The database stores whale photos (Left and right dorsal and fluke photos) with other supporting data such as location and time of the sighting, behaviour and any other group members (including calves) that are present. The photos are scored against a standardised template that originated with the US National Marine Mammal Laboratory system that Sally Mizroch developed back in the late '80's (Mizroch et al. 1990). More information can be found at http://www.alaskahumpbacks.org/flukeIDcatalog.html. To search for a match the scored values are entered into a search template and then the database finds other photos that have been scored the same. The user then decides if there is a match or not and therefore the system provides "semi-automated matching". CWR have developed queries within their database to assist with exporting data for analysis and for their reporting requirements to industry. More details can be found here http://www.cwr.org.au/research/humpbackwhales/photo.html

Happywhale

The custodian of this system is Ted Cheeseman and his vision is to be able to match humpback whale flukes globally. The system uses photo processing algorithms (similar to Flukebook) to match a fluke to the existing catalogue of flukes. The program aims to facilitate tracking of whales globally and therefore it is encouraging contribution from citizen scientists, tourism sector and the research community to optimize the number of individuals contained in the data catalogue. Currently Cascadia Research http://www.cascadiaresearch.org/ and Allied Whale https://www.coa.edu/allied-whale/ contribute their photo-ID data to this program. Cheeseman has also secured agreements with multiple researchers across the North and South Pacific Oceans to contribute data to the system. If a match is achieved this is reported to the contributor as well as future resights of this individual, similar to Wildbook/Flukebook. The algorithms have recently been improved via a Kaggle competition/funding and reportedly this system is performing well (>90%) for matching known/existing datasets such as the one Fluke Matcher was tested on the performance was 99.7% accurate and missed matches were due to poor photo quality. Another performance test on 9000 Alaskan flukes produced similar accuracy of 99.5%. More information can be found at https://happywhale.com/home. Metadata can be exported based on photo or encounter (e.g. sightings info, location, individual ID, etc.) but requires a request to the administrators to get exports of individual sighting histories (e.g. if you want a list of all matches to your catalogue).

Whale Tale

This is an on-line application that was initiated several years ago and co-funded through the Australian Marine Mammal Centre and on-line crowd sourcing. It appears to be targeted at citizen scientists contributing their fluke photos to a community catalogue. The fluke photos are processed and graded (manually) for photo quality and then classified according to black and white pigmentation type.

By classifying the flukes it enables researchers to compare flukes of the same pigment type, eliminating many non-matches without actually comparing the photos. In this way it is a “semi-automated” matching system and the same approach as used by CWR and Sally Mizroch (Researcher focusing on photo-ID and cataloguing of humpback whales in North America).

This Whale Tale initiative apparently has had limited uptake and does not appear to be currently maintained http://www.matchmywhale.org/ according to the website.

4 Recommendations

Processing photo-ID photos

Photo processing will need to be undertaken to create a catalogue, regardless of the database system used. This could be done using software included in the corporate Microsoft suite and then compiled in powerpoint with an individual whale per slide as was done in 2018. However, a photo editing software with cataloguing capability would be preferable to manage large datasets of photos. Adobe Lightroom Classic CC or ACDsee are both good options that we’ve tested and are recommended by other cetacean researchers (Chandra Salgado-Kent and Dan Burns). They are however expensive, proprietary licenced software which would potentially require multiple licences purchased for multiple people to work on the same dataset. A free alternative is Daminion which, whilst not visually as polished, has very similar functionality to the proprietary software and would be recommended.

Photo-identification catalogue system

Where data will be gathered annually as part of a long term research or monitoring program, a photo-identification catalogue is the best choice of system for data storage, maintenance and processing for analysis. Given DBCA Exmouth District staff are currently using Wildbook for whale shark data, are familiar with this system and have found that it meets their needs, then Flukebook (a Wildbook derivative) is a logical choice for management of the data associated with the humpback whale in-water interaction industry.

Flukebook in its current state focuses on whale flukes for individual identification but the capacity to match dorsal fins is in development and T is anticipated within the next year. There is the potential for linking Flukebook with other applications such as the onboard EMS used by the Commercial Tour Operators at Ningaloo which would

increase its application to relevant management questions related to the tourism industry such as the number and length of interactions with individual whales.

Recommendation: We recommend that experienced and trained volunteers (if additional resources are unavailable) are engaged by DBCA to process and prepare photos using Daminion in readiness for inclusion in Flukebook.

5 References

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Table 1 – Summary of the photo-identification catalogues currently available and the pros and cons identified with each system as well as the current users of each system.

System/Software	Pros	Cons	Current users	Estimated cost
Data management system				
Flukebook	• Freeware • Survey data accommodated as well as fluke photos for photoID • Others using for humpback whales • 'One stop shop' i.e. already used by DBCA for whale shark photo ID data • Uses new technology and multiple algorithms to match i.e. pigmentation and trailing edge of fluke (multiple algorithms increase chances of independently matching as they are looking at different features, i.e. increases the odds of getting a match) • Photos imported and no reference points need to be created • Has large patronage, support and anticipated longevity • On-line which allows external users to log in remotely and multiple contributors of data e.g. tour operators external to DBCA as well as staff. • Hundreds of contributors. • Capacity for millions of photos. • Photo resolution is not constrained. • Fast matching process ~3 minutes for hundreds of photos.	• Database hosted by an external agency • Doesn't currently accommodate humpback whale dorsal fin photos but this capacity is anticipated within the year. • Sub optimal performance of algorithms and duplication of matching (via 3 different algorithms) requires validation of potential matches by user time consuming • Not open platform model, security and permissions are set high so that contributors can only see their own dataset/catalogue and this does not encourage collaboration or matching between data custodians or locations (this could be changed to be consistent with Wildbook open platform model). • For larger datasets (thousands or more photos) these runs may take longer i.e. could be left to run over night.	Dan Burns, Trish and Wally Franklin (testing)	Free

	• Automated notifications to the data owner when a new match is found for one of their photos			
Fluke matcher	• Survey data accommodated as well as fluke photos for photoID • Accommodates partial fluke photos for photo ID • Freeware • Instructions are clear from publication and could easily be replicated • Proven on dataset of 860 HBW individuals from Eastern Australian stock • Photo quality grading is automatic • Take 30 seconds to compare 1000 photo. • Photo resolution is not constrained.	• Number of individuals is limited to 5000 images. • Takes 5-6 minutes per whale to enter into catalogue as reference points need to be identified • Old technology that does not have current support • Only accommodates flukes not dorsal fins • Individual install on computer therefore just matching within catalogue not to other datasets as not online application. • We could not get software to run on DBCA computers	SCU University Eric Kniest Dan Burns	Free
Filemaker pro Centre for Whale Research	• Survey data accommodated as well as fluke photos for photoID • Holds thousands (~6000) of individuals from WA Breeding Stock D (private custodianship CWR) with hundreds (~300) resights	• Old technology supported by single technician • Data accessibility/sharing issue • Semi-automated matching rather than using new technology such as AI but most new methods require validation/verification anyway	Curt and Micheline Jenner (CWR) Christ Burton	Provided to DBCA freely upon request but a significant amount of IP has gone into design and therefore not openly distributed.

Happy Whale	• Freeware • Others using for humpback whales (including photos from the Great Barrier Reef supplied by Blue Planet Marine consultancy) • Other species accommodated • Uses algorithms to match ie • Has large patronage, support and anticipated longevity • Online which allows external users to log in remotely and multiple contributors of data e.g. tour operators external to DBCA as well as staff. • Map interface allows easy visualisation of sightings and contributions across a wide geographical area • Takes ~3 minutes per batch of 100 – 200 photos to match against all known whales in the system. • Can accommodate hundreds of thousands of photos. • Can accommodate large file size of high photo resolution (up to 500mb in a single batch) • Photos can be uploaded as batches • Photos can be filtered by their photo quality grade score (although the scoring is manual) • Automated notifications to the data owner when a new match is found for one of their photos	• Database hosted by an external agency therefore data access issues • Batch upload is limited by connection speed • Publicly displayed photos are down-sampled in their resolution • Photo grading is not automatically assigned but manual • Data export (e.g. sighting history) is upon request to administrators so control and access to data may be an issue and a time lag as this would not be immediate.	Ted Cheeseman (PhD student at SCU co-supervised by Dan Burns)	Free
Whale Tale web application	• Engages community similar to Flukebook and Happywhale	• Low patronage i.e. only a dozen contributors and five matches	Pacific Whale Foundation	Free

	• Simple system to match that uses standard classification by pigmentation type but would be matching within catalogue as no local contributors	• Does not appear to be currently maintained • ~1000 photos total stored • Hosted by an external agency and therefore data access issues • Longevity and currency unconfirmed		
Photo editing software (limited capacity to store survey/sighting data)				
Adobe Lightroom Classic CC	• Dorsal fins could be accommodated as well as fluke photos • Tagging capability from set keyword list • Keywords are added and then checked from a list therefore misspelling and typos are avoided and consistency maintained • Batches of photos can be renamed and tagged with same keywords simultaneously • Flexibility in the order/folder structure used by the user to sort the photos.	• The metadata can be exported as a csv file with a separate record for each row. A cost is associated with this as a plugin is required (~$11USD). • Expensive (~$15 per month) • Proprietary software i.e. each computer/person needs a licence • Character and tag limit • Strict user protocols necessary for spelling and order of keyword tags • Time taken to use new application may be longer than other semi-automated applications	Dan Burns (for dolphins) Chandra Salgado-Kent (whales and dolphins, multiple species)	Annual subscription ~ ~$170
ACDSee	• Tagging capability from set keyword list • Keywords are added and then checked from a list therefore misspelling and typos are avoided and consistency maintained • Batches of photos can be renamed and tagged with same keywords simultaneously	• Cost but can be purchased one-off • Proprietary software i.e. each computer/person needs a licence • No capacity to store survey data i.e. not a relational database • Time taken to use new application may be longer than other semi-automated applications		One off payment of ~$160 AUD
Daminion	• Freeware • Dorsal fins could be accommodated as well as fluke photos	• No file export capability of metadata • Photo editing is external to program (in Microsoft office photo editor)		Free

	• Tagging capability from set keyword list • Keywords are added and then checked from a list therefore misspelling and typos are avoided and consistency maintained • Batches of photos can be renamed and tagged with same keywords simultaneously	• Time taken to use new application may be longer than other semi-automated applications. • Interface appearance very basic but functionally similar to other applications (e.g. Lightroom and ACDSee)		