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REVIEW OF REGULATIONS, RECOMMENDED PROTOCOLS, AND MITIGATION FOR THE USE OF AUTONOMOUS UNMANNED VEHICLES IN THE STUDY OF MARINE MAMMALS

Figure 1. Harbour seal haulout group imaged from aerial AUV platform. Photo credit: Jack Lawson.

CONTEXT

In 2015, the Species at Risk Management Division (SARMD) reviewed *Species at Risk Act* (SARA) permit applications for research on marine mammals that involved the use of Unmanned Aerial Vehicles (UAVs; aka. drones). Prior to issuing a permit under SARA, Fisheries and Oceans Canada (DFO) must ensure that all feasible measures will be taken to minimize the impact of the activity on the species (SARA Section 73.3(b)).

Drones are a relatively new technology with great potential to be used in the study of marine species. Anticipating an increase in applications for research involving the use of drones, SARMD is seeking a review of any known impacts of drones on marine mammal Species at Risk, as well as any recommended mitigation measures that can be used to minimize impacts.

The intent of this request is to ensure national consistency in the Science advice provided with respect to the use of drones in marine mammal SAR research. This will in turn result in more consistent permit reviews and permit conditions; and a reduction in repeated requests to Science for stand-alone advice on the same activities. Ultimately, the objective is to provide advice regarding protocols and mitigation measures to avoid and/or minimize harm, harassment and mortality when using drones/UAVs to study marine mammals.

This Science Advisory Report is from the national peer review February 26, 2018 - March 2, 2018, on Protocols and recommended mitigation for the use of drones in the study of marine mammals[1]. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- The use of autonomous unmanned vehicles (AUVs) for wildlife research has increased rapidly in recent years as AUV capabilities increase and costs decrease. AUVs present new possibilities for improving and extending collection of vital data and are predicted to increasingly be integrated into data collection protocols.
- There have been few studies to examine the effects of AUVs. Noise and visual cues from the AUV (or its shadow) are the most common sources of disturbance, regardless of species or AUV type.
- The few studies of pinniped response to AUV approach show that responses, if they occur, vary amongst individuals, populations, and species depending on context. Therefore, potential impacts of AUV use should be assessed on a case-by-case basis.
- Cetacean behavioural responses to AUVs may be more likely to be driven by visual or tactile cues (e.g., rotor wash) than by acoustic modalities but might depend on the higher hearing range of the species. Also, sound does not propagate well from air to water.
- In Canada, rules and operational reporting requirements for AUV use have been established by Transport Canada, although these are changing. Transport Canada does not require reporting of animal responses to AUV use. Regulations in other international jurisdictions vary, with a range of requirements.
- Currently, Canadian Aviation Regulations provide an exemption that allows an AUV to be flown for commercial use (including research) without a special permit, but with specific operational requirements.
- Directed studies of the responses of marine mammals to AUVs in different contexts are needed to identify and assess the potential impacts of this technology.
- Results of such studies should be captured in a national database, and in a standardized format to facilitate development of nationally consistent mitigation measures.
- Permitting and reporting processes regarding the use of AUVs for marine mammal research must include: (1) development of policies regarding AUV use, (2) clarifying the level of reporting detail required of AUV operators, and (3) development of a document outlining best practices for AUV operations near marine mammals based on existing research and the results of required reporting. Such a document could be developed by a national working group.

[1] The science advice should be taken within the context of the subject matter knowledge at that time.

- While acknowledging that employing AUVs can mitigate the impacts associated with larger platforms, based on current information, additional mitigation measures should include using the smallest AUV capable of fulfilling the project requirements (least invasive), operating the AUV at the furthest practicable operating distance from the mammal, operating the AUV when motor sound propagation conditions are the least possible, and maximizing the range to the launch platform.

INTRODUCTION

The use of autonomous unmanned vehicles (AUVs) for wildlife research has increased rapidly in recent years as AUV capabilities have increased and costs decreased. Two classes of AUVs have been particularly common in marine mammal research: helicopter-type multiple rotor aircraft, and fixed-wing, aircraft-like platforms. The uses of aerial AUVs fall into two categories:

1. rotary AUVs flown at lower altitudes and close-proximity to focal animal(s) to collect specific data, such as samples from cetacean exhalations, and
2. “overflight” by fixed-wing AUVs at higher altitude in a defined pattern collecting imagery in a way similar to manned surveys.

AUVs have been used as an alternative to manned aircraft for aerial wildlife surveys and are often reported as a more effective, cheaper, safer, and less disturbing option. Particularly, AUVs can reduce data collection errors arising from observer fatigue and variation in platform flight path. As well, AUVs eliminate the need for researchers to assume the risk of being on an aerial platform and are considerably smaller and less noisy than manned aircraft (Table 1 and Figure 1).

At angles greater than 13˚ from the vertical, much of the sound from an aerial source is reflected from the water’s surface and does not penetrate into the water, particularly with calm seas or deep water. Further, the higher frequency sounds produced by AUVs do not propagate into the water as well as would lower-frequency sounds. Thus, unless the AUV and the marine mammal are both close to the same point near the water’s surface, received sound levels will be low.

Table 1. In-air sound levels (dB A-weighted) for DJI-brand multirotor AUVs, with a professional decibel meter and the AUV hovering. Other in-air sound levels are included for comparison. In air, an increase of 6 dB represents a doubling of sound energy.

Sound Source	Received Sound Level (dB)
Quiet library	30
DJI Phantom 3 on ground	38
DJI Phantom 3 at 3 m	73
DJI Phantom 3 at 46 m	58.5
DJI Phantom 3 at 335 m	54.5
DJI Phantom 3 at 366 m	49.5
DJI Phantom 3 at 396 m	45
Raven fixed-wing AUV at 100 m	50
Scan Eagle fixed-wing AUV at 100 m	66
DJI Phantom 2 at 3 m	75.8
DJI Phantom 4 Pro at 3 m	76.9
DJI Inspire 2 at 3 m	79.8
deHavilland Twin Otter at 305 m	77.4[a]
Bell 206 or 407 helicopter at 100 m	95
Normal conversation at 1 m	60-65
City traffic (from inside car)	85
Truck traffic (from nearby)	90

[a] this level is for power levels set for take-off performance. At normal survey airspeeds the sound level would be less.

Despite increased use of AUVs for research purposes, few studies have systematically assessed impacts of AUVs on marine mammals. From existing studies, noise and visual cues from the AUV (or its shadow) were identified as the most common sources of disturbance, regardless of species or AUV type. Marine mammals that breed and rest on shore, such as pinnipeds, may be most sensitive to AUV noise and visual cues, but marine mammal responses to AUVs vary greatly depending on species, type of survey, context of exposure, environmental conditions, previous disturbance, and AUV type. Much of the data on the responses of marine mammals to AUVs has been collected opportunistically as a by-product of studies rather than dedicated, empirical studies of exposure-response relationships. Hence, there may be an under-reporting of cases in which animals did not respond to AUVs.

ASSESSMENT

Review of primary or grey literature on measured, or potential, impacts of AUVs on marine mammals

Pinnipeds

When pinnipeds are hauled out on shore (e.g., in rookeries), they may flush suddenly into the ocean if disturbed. Especially if a large number of individuals are involved, a flushing event or stampede can lead to individuals sustaining serious injuries or being killed.

Projects that directly studied the effects of rotary and fixed-wing AUVs on pinnipeds, for species such as grey (*Halichoerus grypus*), harbour (*Phoca vitulina*), Antarctic fur (*Arctocephalus gazelle*), Weddell (*Leptonychotes weddellii*), and leopard seals (*Hydrurga leptonyx*) at haulout sites concluded that responses were substantially variable depending on breeding status, moult status, animal habituation to human disturbance, AUV model, altitude of flight, etc. As disturbance of seals at haulouts can depend on many factors and can be with or without obvious cause, non-systematic assessments of disturbance by AUVs should be interpreted carefully. Compared to the traditional survey aircraft or helicopter platforms, overflights by fixed-wing AUVs have been shown to elicit considerably weaker (or no apparent) reactions by pinnipeds such as ribbon (*Histriophoca fasciata)* and spotted (*Phoca largha*) seals on ice. A single study did not find significant negative responses to the approach of a small wheeled AUV vehicle, and the grey seals habituated quickly to its presence.

Cetaceans

Due to loss of acoustic energy as it passes through the air-water interface, behavioural responses of cetaceans to AUVs are more likely to be driven by visual than by acoustic modalities therefore the potential for disturbance likely increases as AUVs enter the visual range of cetaceans (i.e., lower altitude) and needs to be considered. To date few studies have attempted to identify and/or quantify disturbance to cetaceans caused by AUVs.

Rotary AUVs have been used to collect data on cetaceans such as blue (*Balaenoptera musculus*), gray (*Eschrichtius robustus*), humpback (*Megaptera novaeangliae*), sperm (*Physeter macrocephalus*), and fin (*Balaenoptera physalus*) whales. None of these studies showed any more avoidance responses toward a rotary AUV flown directly over them at low altitude than they did to more standard photo identification approaches using small vessels. Similarly, observations of a rotary AUV flown over groups of killer whales (*Orcinus orca*) at an altitude of 35-40 m did not elicit any responses from the whales, and the researchers concluded that these whales were not aware of the presence of the AUV. However, neither of these studies directly quantified cetacean responses to the AUVs, so it is possible that the whales responded in subtle ways that were not detectable though simple observation. Amateur video taken using a quadcopter flow over killer whales in shallow coastal waters showed that these whales could detect the AUV flying overhead and may have oriented in the water to view the aircraft – perhaps responding to the lights on this model of AUV.

Bowhead whales (*Balaena mysticetus*) showed no obvious responses when overflown by a fixed-wing AUV, which is not surprising considering that bowheads don’t respond to noisier aircraft used to take aerial photographs of them. Similarly, migrating Australian humpbacks did not appear to react to the overflight of a ScanEagle AUV overflying them at 732 m.

There have been no quantitative studies of reactions of pinnipeds or cetaceans to the operation of underwater AUVs such as those used to collect underwater sound data, although the near approach of several types of remote operated vehicles evokes startle responses from loggerhead turtles (*Caretta caretta*).

A review of AUV operational reporting requirements during the study of marine mammals

Canada

Just as the methods for assessing and mitigating impacts of AUVs on wildlife are still in development and may vary depending on numerous factors, the framework for the regulation of AUVs in Canada is evolving and the current regulations vary depending on factors such as the user (private versus commercial), AUV weight class and AUV use. Specifically, within the current regulatory framework developed by Transport Canada, the use of AUVs for research purposes qualifies as commercial use. A researcher must obtain a Special Flight Operations Certificate (SFOC) from Transport Canada to fly an AUV. As per Canadian Aviation Regulations (Transport Canada), there are exemptions based on UAV weight for requiring a SFOC. However, if researchers are unable to meet the exemption conditions, they must apply for a SFOC for every mission that they fly. Transport Canada noted that the current SFOC process had caused frustration for AUV users, particularly since the number of applications increased 435% from 2013 to 2015.

Prior to issuing SARA S. 73.3(b) or Fishery General Regulations S.52 permits, DFO must ensure that all feasible measures are taken to minimize impact of an activity, such as AUV use.

Other countries

The regulation of AUV use in other countries varies and usually differs from that in Canada. The United States is in the process of making changes to its AUV use regulations. In 2016, a new set of regulations for non-hobbyist AUV operators was issued by the Federal Aviation Administration (FAA). Notable differences from the current Canadian regulations include:

1. an online portal through which operators can apply for waivers that will allow them to bypass certain restrictions, given they can demonstrate that the operation can be carried out safely under a waiver, and
2. the requirement that AUV pilots are at least 16 years old and hold a remote pilot airman certificate with a small AUV rating (obtained by passing an FAA-approved aeronautical knowledge test), or are under the supervision of someone who has this certificate.

The European Union also made changes to its AUV regulations, with new rules focussing on safety, security, privacy, data protection, insurance and liability. Similar to AUV regulation in Australia, South Africa, and the United States, the new European Union rules will require AUV operators to be licensed. Many countries are taking a similar, precautionary approach to regulating AUVs, and wildlife research has been hindered by the slow pace at which legislation is being changed to better accommodate AUVs.

Recommendations for AUV operations

Operators should choose the least invasive platform, capable of meeting the objectives of the study, in terms of size and noise output (e.g., a smaller AUV, without lights or brightly coloured markings).

If possible AUVs should be operated in conditions or ways to limit marine mammals' exposure to acoustic and visual stimuli originating from the AUV; this might mean that operations cannot be conducted on very quiet days, or at dawn and dusk if the AUV has lights.

Operators should move the AUV into the proximity of the study animal slowly and from an altitude higher than the planned minimum approach height. If during this process significant responses are observed (e.g., animals begin to flush from a haulout location, animals stop feeding), the AUV should withdraw from the vicinity of the animals.

Data on the responses (or lack thereof) to AUVs on the study animal(s) should be submitted upon completion of the permitted AUV activity. This data should be amalgamated and further summarised within a national AUV study data repository within DFO.

Behavioural or physiological responses should be reported consistently with every authorized AUV project, and the responses clearly categorized. This could be facilitated by a standardized protocol for reporting behavioural responses to AUVs.

Sources of Uncertainty

- A recent review of AUV use in research highlights the lack of information regarding both the effects of AUVs on marine mammals and any recommended mitigation measures that can be used to minimize these effects. Most studies of AUV use near marine mammals have not quantified contextual factors such as the received sound levels or controlled for the influence of confounding factors (such as the proximity of vessels from which to launch the AUV during studies of cetaceans). This complicates development of exposure-response relationships for models of impact and mitigation methods.
- There may be recently published or grey literature reports containing pertinent data that could change the advice in this SAR.

CONCLUSIONS AND ADVICE

This review was intended to be used as the basis to develop policy and protocol(s) to ensure national consistency in AUV operational permit review and in the development of permit conditions, and to reduce the need for repeated requests to Science for stand-alone advice on the same activities. Unfortunately, the few studies of AUV available for review serve to demonstrate that different individuals, populations, exposure context, and species appear to vary in their responses to AUVs.

Therefore, potential effects may still need to be assessed on a case-by-case basis, considering factors such as species, type of survey, alternative methods, environmental conditions, previous exposure history, and AUV type. Although such response variability will complicate developing an overarching AUV operations protocol, if no action is taken, negative impacts to marine mammals may result from the inconsistent requirement and application of mitigation measures to reduce effects of AUVs (if any).

The goals of better understanding and coordination of AUV operation in Science would be facilitated by a national AUV working group. This group could lead development of minimum standards or best practices for implementing AUV-based research.

ADDITIONAL CONSIDERATIONS

The rapid development and deployment of AUV systems in scientific research within and outside DFO compel development of national policies and protocols in the near term.

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SOURCES OF INFORMATION

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