Applying unoccupied aircraft systems to study human behavior in marine science an...

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Introduction

The use of Unoccupied Aircraft Systems (UAS, aka drones) in marine science is rapidly increasing (Johnston, 2019). Researchers across a range of disciplines are now using drones to collect data on a variety of natural features and phenomena, from counting seals (Seymour et al., 2017) and measuring whales (Christiansen et al., 2018), to improving the assessment of coastal habitats (Gray et al., 2018a). This rise in the use of drones in marine science stems from the growing availability of affordable and easy-to-use systems, coupled with their ability to collect high resolution information in an essentially on-demand manner (Johnston, 2019).

The majority of these research studies deploy UAS to collect various types of information on inanimate components of marine systems (e. g., beach topography – see Seymour et al., 2018), vegetation (e. g., coastal wetlands – see Gray et al., 2018a) or animals (e. g., sea turtle biology, ecology, and density – see Sykora-Bodie et al., 2017 ; Gray et al., 2018b ; Rees et al., 2018). The information generated can be used in a variety of pure or applied ecological or environmental studies, including coastal management and protected species population assessments, and can contribute to our understanding of how coastlines evolve (Seymour et al., 2019). However, simply studying inanimate and non-human animal components of marine ecosystems is rarely sufficient to solve pressing conservation problems. In fact, in many cases both collecting data on human behavior and establishing how to manage the effects of human behavior are critical for many conservation efforts. Given the capabilities of UAS to collect high resolution

information, they have significant potential for studying human interaction with marine and coastal systems, and can be used for both pure and applied purposes to that end. For example, high resolution aerial imagery from drones could be used to quantify how humans use marine areas under varying conditions, and also could be applied to enforcement efforts through detecting illegal activities and facilitating enforcement efforts.

The use of UAS in humanitarian contexts is also becoming commonplace (Emery, 2016). Drones are used for disaster relief, including scouting areas affected by natural events such as earthquakes and delivering aid to people in remote locations (Emery, 2016). In terrestrial systems, drones are being applied to human wildlife conflicts such as poaching, although with variable results (Mulero-Pázmány et al., 2014). In marine systems, some studies have indicated that drones can be used to facilitate management of fisheries and to take images of protected areas (e. g., Kopaska, 2014). However, few – if any – published studies focus on how researchers can use drones to quantify *human* behavior that affects marine environments.

Some of the existing legal rules associated with flying drones in the US National Airspace System (NAS), present clear challenges for using UAS to study human behavior in marine systems. Chief among these are regulatory limitations associated with public safety, such as the baseline restriction on commercial operators in the United States on overflying people 1 . For example, FAA certified remote pilots are prohibited from flying over people unless (1) they receive a waiver from the FAA, or (2) those people are directly participating in the operation 2 . However, because these safety

issues are established in regulation, and there are examples illustrating how they can be addressed through a waiver (e. g., State Farm Mutual Automobile Insurance waiver from the FAA for flights over people) or operationally through best practices (e. g., collecting data obliquely), they are not a focus of the present study.

Perhaps the most difficult challenges occur where researchers must apply best practices and conduct their work in a manner that does not invade the privacy or erode the security of people being studied (see Resnik and Elliott, 2018). Some authors have pointed out that using drones for science raises significant concerns in these areas (e. g., Sandbrook, 2015); however, no comprehensive set of best practices exists to guide researchers in their efforts to explore the use of drones in the study of human behavior in marine systems.

The present study focuses on several other, less explored, legal issues associated with using drones to study humans in a marine science and conservation context. Specifically, we address two hypothetical use cases focused on how humans make use of natural resources in marine and coastal environments. The first case considers the potential use of drones to collect information on recreational fishing effort in the coastal oceans. The second case focuses on the potential use of UAS to monitor how humans use coastal protected areas such as national parks or seashores. In both hypotheticals, we introduce the regulatory system involved, describe the scientific question and approach, and then explore some of the legal implications of using drones to collect information about human uses of, and impacts on, the

environment. Finally, we provide recommendations for conducting such research without invading privacy or eroding personal security. While some of the issues addressed here are regional in nature, much of what is revealed is applicable to other locales in the United States and provides a framework and useful guidance for international assessments of this type.

Discussion

The use of drones to track, monitor and evaluate human behavior has clear implications for privacy. Drones have the ability to view and record wide swaths of area, so while a particular drone may be focused on the shoreline, it could also be capturing video of someone sunbathing in a nearby backyard (Luppicini, 2016). Personal privacy is often considered to be " so integral to our identity and autonomy that it [is] a social good fundamental to our society" (West and Bowman, 2016). Privacy issues have been a concern with many other similar technologies, such as airplanes, security cameras, and satellites (Mintz, 2016). But drones present new privacy implications because of their affordability, size, mobility, efficiency, and endurance. Drones are small and can maneuver to new locations to capture more up-close-and-personal data (Singer, 2013). And, in contrast to their manned counterparts (which rely on the human consciousness for what to capture and store), drones are constantly (and often autonomously) taking in information (Singer, 2013) 3 . Finally, there are heightened privacy concerns when drones accumulate large amounts of data over time (West and Bowman, 2016). A drone is able to fly over the same area repeatedly, so it is able to assimilate a more nuanced understanding of the activities it records as compared to a single snapshot.

Despite these concerns, the FAA's regulations governing the use of drones explicitly state they do not address privacy. As the FAA explained in the preamble to its final rules, the agency's " mission is to provide the safest, most efficient aerospace system in the world, and does not include regulating privacy." 4 Although lawsuits challenging the agency's refusal to address privacy considerations have been unsuccessful in federal court 5 , state laws to protect privacy interests implicated by the use of drones are developing rapidly. 6 For example, Florida recently enacted legislation prohibiting anyone from using a drone to collect images 7 of individuals or their property without their express written permission, where the individual has a reasonable expectation of privacy 8 . North Carolina has enacted legislation making it a Class A1 misdemeanor to " publish or disseminate, for any purpose, recorded images taken by a person or non-law enforcement entity through the use of infrared or other similar imaging technology attached to an unmanned aircraft system ... and revealing individuals, materials, or activities inside of a structure without the consent of the property owner." 9 North Carolina also prohibits using drones to conduct surveillance of " a dwelling occupied by a person and that dwelling's curtilage without ... consent," or of " private real property without the consent of the owner, easement holder, or lessee of the property." 10

Currently, there is very little case law governing the private, non-governmental use of drones, whether for recreation or research, and the recent trend of cases governing other types of technology that raise similar ethical concerns suggests that the courts are not willing to substantially intervene or to fully outline what a right to privacy entails. 11 It is

nevertheless important for researchers using UAS platforms to be familiar with the laws protecting individual privacy and to develop protocols to avoid violating those interests.

U. S. Constitution 4th Amendment Considerations

The Fourth Amendment to the U. S. Constitution provides that " the right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated." 12 The courts have interpreted this clause as imposing an obligation on the government to respect the reasonable privacy and security interests of individuals, thereby protecting individuals from unreasonable searches and seizures 13 .

Although the protection afforded by the Fourth Amendment applies only to government action in the context of law enforcement, a search or seizure carried out by a private individual could implicate the Fourth Amendment if that private entity is considered a " state actor" – i. e., that entity is performing the action under contract with a law enforcement agency, and the information produced is used for law enforcement purposes. As a consequence, when a private entity, such as the Duke University Marine Robotics and Remote Sensing Lab (MaRRS, a drone research lab in North Carolina), is conducting research pursuant to a contract with a government agency, there are several questions it must ask to avoid the possibility that it might be alleged to be violating a private individual's Fourth Amendment Rights: (1) does the contract make the Lab a " state actor" for purposes of the Fourth Amendment; (2) does the method of obtaining the information constitute a " search" or " seizure"; and (3) did the private individual whose

information is collected by the Lab's drone have a reasonable expectation of privacy?

(1) Is the private entity operating the drone a " state actor" by virtue of a research contract with government agency?

Pursuant to federal law, private actors generally are not required to afford individuals any constitutional rights 14 . However, there are some exceptions to this basic rule, and courts have tended to look at each situation on a case-by-case basis 15 . A widely recognized exception applies when an individual is performing the action under contract with a law enforcement agency or with the participation or knowledge of any governmental official. Under such circumstances, the individual may be considered a state actor 16 . Because state actors are held to the same laws and regulations as the government itself, they must take care to protect the constitutional rights and freedoms of other individuals. In the context of monitoring human behavior, extra care must be taken to protect privacy rights.

(2) Is the drone activity a " search"?

The courts have long debated what types of actions may constitute a " search." The Supreme Court has observed that in the 18th Century (when the Fourth Amendment was adopted), " to ' search' meant '[t]o look over or through for the purpose of finding something; to explore; to examine by inspection; as, to *search* the house for a book; to *search* the wood for a thief."' 17 However, the courts have departed from this common understanding of a search to rule that in some instances, a " search" as the

term is commonly understood may not be deemed a " search" for purposes of the Fourth Amendment. For example, the nation's courts have looked for a physical invasion – a trespass – to determine whether a search has taken place. Thus, the Supreme Court has consistently determined that obtaining information that is readily observable to the public *does not* constitute a search. In *Dow Chemical v. US* , the Court determined that EPA's employment of a commercial aerial photographer to take photographs of a Dow manufacturing facility did not constitute a search. Key to the Court's determination was the fact that the photographer used a standard aerial mapping camera (rather than highly specialized technology not in general use) 18 and took the photos from public airspace. Relying on earlier precedent, the Court ruled that the open areas of the industrial complex were akin to " open fields" in which a common person would have no reasonable expectation of privacy 19 . In contrast, the Court has determined that the placement of a GPS device on a personal vehicle to monitor and track the vehicle's movement *does* constitute a " search." 20 Critical to the Court's determination in the GPS case was that the law enforcement agency placed a tracking device on the vehicle – i. e., physically intruded on the individual's " effects" – for the exclusive purpose of finding something or obtaining information 21 .

Jones and *Dow Chemical* concur that a " search" involves looking for and obtaining information. In both cases, the Court focused on whether a physical invasion had taken place. However, the reach of the Fourth Amendment extends beyond traditional notions of property and includes broader notions of personal privacy. The Supreme Court made this clear in

the landmark case *Katz v. U. S.* , which involved eavesdropping on a conversation conducted in a public phone booth. In *Katz* , the Supreme Court established that a warrant is required for a search or surveillance if the individual in question is operating under a " reasonable expectation of privacy." 22 According to the Court, the key to determining whether the expectation is " reasonable" is whether the person seeking the protection of the Amendment had a legitimate expectation of privacy in the invaded place, and whether the expectation is one that society is prepared to acknowledge as reasonable. Any information the individual wishes to protect cannot be " exposed" to the " plain view" of outsiders. As Justice Harlan explained in his concurrence, "[w]hat a person knowingly exposes to the public, even in his own home or office, is not a subject of Fourth Amendment protection." 23

This phrasing has been analyzed by a number of legal scholars. They have reasoned that "[w]hen a person takes what is otherwise personal and shows it publicly, she effectively invites or agrees to the predictable public scrutiny that will follow. Once this self-exposure occurs, no entitlement to privacy remains" (Colb, 2002). Others concur with this assessment, stating that "[a] person moving in public ' has no reasonable expectation of privacy in his movements from one place to another."' (Koerner, 2015) Thus, a search of an object or area in which a person has no reasonable expectation of privacy is, in a legal sense, not a " search" at all.

(3) Does the research subject who is the object/target of the drone observation have a reasonable expectation of privacy?

The Supreme Court's precedent on the question of the " reasonableness" of the expectation of privacy in the area searched requires consideration of the specific privacy precautions taken by the affected person, such as concealing one's public movements or wearing specific garments to conceal any smells or agents (Koerner, 2015). Courts will also consider the importance of the governmental interest occasioning the search, and the degree to which the search is tailored to that interest and minimizes the intrusion 24 .

When it comes to the protections afforded by the Fourth Amendment, " the home is first among equals." 25 The amendment's protections extend to a home's " curtilage" – i. e., " the area ' immediately surrounding and associated with the home,"' including driveways and porches 26 . " The protection afforded the curtilage is essentially a protection of families and personal privacy in an area intimately linked to the home, both physically and psychologically, where privacy expectations are most heightened." 27

But not all aspects of the home and its curtilage are protected. For example, in *California v. Ciraolo* , the Court authorized observation of a private, fenced backyard from an aircraft in order to look for marijuana plants. The Court ruled that because the plane traveled in public airspace, there was no reasonable expectation of privacy in the open backyard 28 . Similarly, in *Florida v. Riley* , the Court ruled that police could use a helicopter flying at 400 feet to look inside an individual's greenhouse for marijuana plants. Even though the plants were being grown inside the greenhouse, there were holes in the roof, and thus it was unreasonable to expect the contents of the greenhouse " to be immune from examination" from the air. Relying on

Ciraolo , the Court emphasized that there had been no physical invasion nor revealing of intimate details, and concluded that the police may see what may be seen " from a public vantage point where [they have] a right to be." 29

While these cases make clear that observations from a public street or the public airspace are reasonable, significant questions remain for those using drones for research purposes. For example, what if the government agent used not a commonly available camera but an infrared sensing device such as forward-looking infrared radiometer (FLIR)? In the 1990s, several United States appellate courts authorized the use of infrared devices to search for and detect excess heat emanating from a home as evidence of the indoor cultivation of marijuana. These courts determined that infrared devices such as FLIR are analogous to the use of police dogs trained to sniff and identify the presence of drugs in luggage, or the search of garbage left outside for collection, and that any subjective expectation of privacy one may have in the heat radiating from one's house is not one that society is prepared to recognize as " reasonable." 30

The Supreme Court disagreed with these rulings, however, and attempted to articulate limits on " the power of technology to shrink the realm of guaranteed privacy." In *Kyllo v. U. S.* , the Court ruled that " obtaining by sense-enhancing technology information regarding the interior of the home that could not otherwise have been obtained without physical intrusion into a constitutionally protected area, constitutes a search at least where (as here) the technology in question is not in general public use." 31 Critical to the

majority’s decision was the fact that the search was of activities taking place inside the home, and that the technology used to detect the heat emanating from the home was not in general use 32 .

Resolving the question whether a particular use of drones could be deemed a violation of the Fourth Amendment is not the end of the inquiry into potential liability for the entity that deploys the drones. Importantly, even if research activities at a private institution such as the Duke MaRRS Lab would not trigger liability under the Fourth Amendment protections – even if it were deemed a “ state actor” in a particular situation – such an institution potentially could be subject to civil liability for invasion of privacy. Moreover, Fourth Amendment jurisprudence informs considerations of privacy in the civil tort context. While illustrative of how courts could interpret the expectation of privacy in such a setting, these constitutional cases should not be regarded as binding case law in the invasion of privacy context (and vice versa). The next section of the article provides a brief overview of the civil tort of invasion of privacy.

The Tort of Invasion of Privacy

“[T]he protection of a person’s *general* right to privacy – his right to be let alone by other people – is, like the protection of his property and of his very life, left largely to the law of the individual States.” 33 There is considerable variation among the states governing civil liability for invasion of privacy. For example, while there are four possible “ invasion of privacy” torts – (1) public disclosure of private facts; (2) invasion of solitude; (3) false light (similar to defamation); and (4) appropriation (i. e., unauthorized use of another’s name or likeness to obtain some benefit) – North Carolina law recognizes only the

first two. Similarly, each state has its own laws governing the use of drones. Consequently, while this section will discuss general principles for privacy torts, it is important to note that any question of potential liability will be decided based upon the circumstances of each state and situation.

The tort of " invasion of privacy" is based on the common law and may be brought against any entity, regardless of whether that entity is considered a private or state actor. A suit for invasion of privacy allows a party to bring a suit against any entity that violates his or her privacy in one of four ways: (1) unlawfully intruding into his or her private affairs (invasion of solitude), (2) disclosing his or her private information, (3) publicizing him or her in a false light, or (4) appropriating his or her name/depiction for personal gain 34 . Each of these versions of the invasion of privacy tort turn on what expectation of privacy the party suing could reasonably expect. Therefore, if someone is surveilled while inside their home, that person likely had a high expectation of privacy and may be able to prove a tort for invasion of privacy (Thompson, 2015). However, if a person is being surveilled in a public place or " even on private property that can be viewed from a public vantage point," he or she likely has little or no expectation of privacy and may not be able to prove an invasion of privacy tort (Thompson, 2015). One exception, however, is " where one's status is changed without [his or her own] volition to a status embarrassing to an ordinary person"; in such cases he or she has a right to be protected from intrusion of privacy (Farber, 2017 , p. 401). As in Fourth Amendment cases, the location in which a person is recorded is a significant consideration.

In order to bring a successful claim for the tort of " invasion of solitude," the party bringing suit must show that there was a physical or electronic intrusion into his or her private quarters that was *highly offensive* 35 . The applicable standard is whether a " reasonable person" of " ordinary sensibilities" would be offended by the intrusion. The invasion must be both " highly offensive" to the reasonable person and " intentional" on the part of the intruder (Thompson, 2015 , p. 15). In general, the intrusion must be " repeated with such persistence and frequency as to amount to a course of hounding," rather than just a single intrusion 36 , 37 . In addition, some states require a showing of mental suffering or shame in order to prevail on an invasion of solitude tort (Thompson, 2015 , p. 15).

For a tort suit concerning the public disclosure of private facts, the party must show that there was a dissemination of truthful, private information which a reasonable person would find objectionable. The two elements for this tort are that the information made public was (1) " highly offensive to a reasonable person" and (2) " is not of a legitimate concern to the public." 38 As with the other variations of the invasion of privacy tort, a key distinction between a successful suit and an unsuccessful one is whether the facts publicized were public or private. This variation, however, also requires that the information be widely publicized to the public at large (Thompson, 2015 , p. 15).

In addition to these considerations, there are related concerns about data security. Commercial drones may also be vulnerable to various forms of cyber hacking attacks (Rao et al., 2016 , p. 89). If data and other

information collected through research are hacked and released, the researcher could be exposed to a tort claim for invasion of privacy; even though the release is beyond the researcher's control, liability theoretically could ensue for negligence in the protection of the information.

Case Study 1: Using UAS to Estimate Recreational Fishing Effort in Coastal Waters

Throughout the country, management of fisheries in state waters is the responsibility of state agencies, typically a division of marine or inland fisheries or a wildlife management agency. For purposes of this hypothetical, we will focus on North Carolina, whose coastal fisheries are regulated by the N. C. Division of Marine Fisheries (DMF). DMF gathers and tracks data on commercial fishing within the state, providing insights into that industry's use of fish resources. DMF is also responsible for monitoring recreational fishing within the state, primarily through the use of license data and intercept surveys at local beaches and public piers and boat launches. The selectivity and randomness of these surveys can generate unreliable estimates of fishing effort and impact, in part because they fail to capture activity launched from private docks, as well as informal fishing efforts (i. e., subsistence fishers). Some argue that landings of some species in recreational fishing are significantly greater than generally estimated (Coleman et al., 2004). Under these circumstances, generating accurate and reliable data on North Carolina's recreational fisheries would better allow the state's environmental and conservation agencies to develop and implement more effective fish and coastal management measures.

Given the need for better data, a straightforward use of UAS would be to fly over the state's estuarine waters and count the number of boats on the water and, possibly, the number of individual fishing rods in use on those boats. Surveys using UAS could be conducted at specified times, with aircraft launched and recovered from either land or boat. Flights could be conducted at altitudes of between 80 and 120 m, collecting imagery with spatial resolution of between 2 and 4 cm per pixel. These data would also include the locations of the boats, and sequential surveys could provide time sequences over the course of a day to reflect the intensity of fishing effort. Although some of this information could be obtained through simple ground-based observations, the UAS platform – which enables observation at altitudes that provide greater geographic coverage and broader understanding of topography – provides far better opportunities to visualize, observe, and map details and features that are not detectable via ground surveys. These survey data, coupled with responses from an ongoing dock survey program – and an understanding of seasonal variations in the species of fish targeted for catch – would improve a fisheries management agency's understanding of the intensity of recreational landings across a number of species.

While recognizing these benefits, such a survey program has potential privacy implications for the individuals whose fishing behaviors would be studied. Therefore, in the event the Duke MaRRs Lab received a request to conduct this kind of survey, it would be prudent to evaluate the following legal considerations:

(a) a recreational angler's expectation of privacy while on the water;

(b) expectations of personal privacy while fishing from a private dock;

(c) curtilage doctrine application to fishing vessels with enclosed living spaces; and

(d) the impacts attributed to the use of different drone imaging techniques.

A Recreational Angler's Expectation of Privacy

In considering whether drone imaging of recreational fishing activities could potentially expose the UAS operator who is conducting the imaging to legal liability, one must consider both the body of federal Fourth Amendment jurisprudence and the reasoning of state courts that have considered an angler's reasonable expectation of privacy in the context of natural resource enforcement. While we could find no case that squarely addresses our hypothetical, the cases we reviewed strongly suggest that recreational anglers have no reasonable expectation of privacy in most situations, whether they are fishing from a boat on open water or from a private dock.

Many courts have analogized recreational fishing to " pervasively regulated industries" in which one's expectation of privacy is eroded merely by participation in that industry (see Kuh, 2015 , pp. 39–41). As an example of the degree of oversight, North Carolina's regulations make it unlawful for any commercial or recreational licensee to refuse DMF agents access to biological data (such as species identification, length, weight, age, and sex), harvest information (such as location, method and quantity of catch), or

other data “ necessary or useful to the conservation and management of marine and estuarine resources from fish in the licensee’s possession.” 39

Such detailed oversight has persuaded the courts that an angler has little expectation of privacy. The California Supreme Court has ruled that the intrusion upon an angler’s privacy that was engendered by a game warden’s search of the catch was minimal, due in part to the fact that anglers “ have voluntarily chosen to engage in an activity that is heavily regulated in order to assure the continued existence of the wildlife of this state for the benefit not only of future generations but for the benefit of current anglers and hunters themselves.” 40 Similarly, in *Hamilton v. Myers* , the Sixth Circuit 41 found that “ everyone who participates in the privilege of hunting has a duty to permit inspections to determine whether they are complying with applicable Laws.” 42 And the Supreme Court of Montana has found that a fisherman who was aware of the inspection requirements attendant upon his licensing had no expectation of privacy in the fishing catch in his live-bait well 43 . The court emphasized that – by participating in a highly regulated activity like recreational fishing – “ anglers must assume the burdens of the sport as well as its benefits.” 44

In addition, courts around the country have consistently ruled that a person’s expectation of privacy is greatly reduced when moving through public areas. As the Supreme Court noted, general protections of privacy do not extend to “ simple visual observations from a public place.” 45 Fishing in open waters is akin to standing in an open field, in which one’s expectation of privacy is greatly reduced, even if that field is privately owned 46 . Based on the “

open fields” doctrine, it is arguable that one’s expectation of privacy would be even *less* when fishing in open waters, which are part of the public trust, and exploiting fish, which are a public resource. The same is true for those who fish from private docks. Most private docks are more accessible and observable than the property Google accessed and recorded from a clearly marked private road, which the Third Circuit 47 found was not entitled to a reasonable expectation of privacy 48 . Consequently, if those docks are built over public trust waters and are open to the air, then one’s expectation of privacy must presumably be greatly reduced.

It may be helpful to analogize observable fishing operations on public waters to the practice of monitoring vehicle license plates on public roads, an activity that the Supreme Court has determined is permissible where “ the officer had a right to be in a position to observe the defendant’s license plate.” In *U. S. v. Ellison* , the Court found that the officer had the right to observe license plates because his observation of those plates took place when the vehicles were located in a public place (a public parking lot) 49 . In this hypothetical, the fishing activity would be taking place on public trust waters that are accessible to everyone. And, because the researchers would be focused on the numbers of fishing rods in the water in a given area rather than the registration of the individual boats or the identity of the anglers themselves, there are no apparent invasions of privacy. To paraphrase one of the scholars cited above (Koerner, 2015), a person fishing in public has no reasonable expectation of privacy in the casting of his rod in one place or another.

Curtilage Doctrine and Enclosed Fishing Vessels

Despite the reduced expectation of privacy when operating in a public space, a particular angler may still be entitled to privacy protections under certain conditions. As discussed above, the Supreme Court has ruled that if one seeks to preserve privacy, even in an area considered to be public, then he or she " may be constitutionally protected." 50 Moreover, privacy protections expand beyond the boundaries of one's residence to include the " curtilage" of a dwelling 51 . Anticipating the potential invasions of privacy concerns that could be triggered by the use of UAS, the state of North Carolina specifically protects " a dwelling occupied by a person and that dwelling's curtilage from surveillance by drones without the occupant's consent." 52

Such privacy protection requires consideration of the question whether a fishing vessel may be considered to be a dwelling, and whether certain parts of the vessel may be considered part of the dwelling's curtilage. North Carolina law does not define " dwelling," nor does it specify what falls within the curtilage. In contrast, Florida law defines a dwelling as " a building or conveyance of any kind, including any attached porch, whether such building or conveyance is temporary or permanent, mobile or immobile, which has a roof over it and is designed to be occupied by people lodging therein at night"; it also specifies that a ship or vessel is included within the definition of a conveyance 53 . Under this definition, a fishing vessel that includes a covered cabin could be considered a dwelling, even if unmoored and used only for short periods of time. In such instances, the curtilage could theoretically include the deck of a boat, just as it would the front porch of a traditional home.

We have located no case law or statute that addresses this specific question. Ultimately, whether and to what extent privacy protections apply to activities on a privately owned recreational fishing boat are questions of state law. Researchers or fisheries agents who use UAS to survey recreational fishing activity can help avoid potential infringements on an angler's privacy by excluding information obtained from covered portions of the vessel and otherwise respecting any attempts by the vessel's occupants to establish privacy (such as erecting a removable shade over the boat deck or mooring the boat behind a blind).

Use of Enhanced Imaging Techniques

As the Supreme Court ruled in *Kyllo* , the general accessibility and commonality of technology used to obtain information is an important factor in determining whether a search is reasonable without a warrant or consent. The Court determined that because the thermal imaging technology used to detect heat emanating from a personal residence was not in general public use, a warrant was required by the law enforcement agency 54 . While surveying the intensity of recreational fishing effort does not qualify as a law enforcement activity, even if conducted pursuant to a contract with a government agency, the Court's focus on the general availability of the technology is instructive for determining whether its use infringes on the reasonableness of one's expectations for privacy in a civil context.

Individual states may have addressed through legislation whether a particular technology has privacy implications. For example, North Carolina imposes criminal liability on the recording, publication or distribution of

images obtained from inside a structure “ through the use of infrared or other similar imaging technology attached to an unmanned aircraft system” without the subject’s consent (see text footnote 9). In the absence of such specific legislation, courts will look to the general use, availability and accessibility of the technology in question to determine whether its use is “ reasonable” under the circumstances. Researchers may feel comfortable using general photography and videography, and even more sophisticated mapping technologies such as that used in *Dow Chemical v. U. S* . Per the ruling in *Kyllo v. U. S.* , less commonly used technologies such as infrared, biological sensors, particle sensors, and chemical sensors may be more problematic due to their advanced abilities to monitor other aspects of the environment that human eyes cannot detect (Vergouw et al., 2016 , pp. 21–45).

In considering whether the use of a particular technology has the potential to violate reasonable expectations of privacy, it may be useful to evaluate whether the technology could be considered to be “ intrusive.” For example, an assessment of night-time fishing activity would likely require the use of infrared technology, which scans at 11 cm/pixel resolution and can “ see” through basic walls or other barriers to detect heat sources of varying intensities. As North Carolina’s ban on the use of this technology in association with UAS implies, technology like this may be considered to violate one’s reasonable expectations of privacy, even when out in the open. As imaging techniques advance in the coming years, there will be heightened concerns about the intrusiveness of those technologies when balanced against the privacy interests of the individual.

To avoid invasions of privacy that could expose researchers to legal liability, the drone operator should not attempt to view any activity shielded or enclosed within a boat or cabin, but instead should focus on activity on the open areas of the boat. Deploying the UAS at heights above 50 feet, e. g., will not only reduce distractions, but also will help avoid invasions of " personal space" and thus privacy. Finally, restricting the surveillance technologies to those that are in general use and limiting aerial surveys to daylight hours can minimize the sense of intrusion and the subjects' sense of vulnerability.

Case Study 2: Using UAS to Assess Visitor Use of Public Lands

Drones are currently being used to conduct aerial surveys in the off-shore waters of Cape Lookout National Seashore to improve understanding of the movement and abundance of sea turtles within and adjacent to the park boundaries. Although sea turtles are the focus of this research, the UAS could capture oblique images of humans who are on the beach or swimming, surfing, fishing and boating in the waters. Based on this experience, it is increasingly clear that it would be simple to use UAS to study human behavior in the park itself – and that the information that could be developed could be used to better manage the park's resources and generate a more robust understanding of the park's economic impact on the surrounding economy.

The Cape Lookout National Seashore is a National Park situated on the coast of North Carolina. The park consists of 56 miles of undeveloped beach stretched over several barrier islands, from Ocracoke Inlet on the northeast to Beaufort Inlet on the southeast. In 2017, some 399, 000 visitors visited

the park, spending an estimated $20. 9 million dollars in nearby communities. This level of spending supported 309 jobs in the local area and generated a cumulative benefit to the local economy in excess of $22 million dollars (National Park Service, 2018). These data, collected largely through surveys of visitors, provide details on the visitors' basic use of the park but omit information about *where* human activities are concentrated within the park itself. Also, because the park is accessible by private boat as well as by the public ferry, these numbers likely underestimate the actual number of people using the park and do not capture spatial information on overall human use patterns.

With UAS, researchers could fill these information gaps – gaps that likely exist in other national, state and regional parks as well. Researchers could fly the UAS overhead and count the number of people within the park's boundaries on a given day, then analyze their movements within the park throughout the day or over time. Surveys could be conducted at specified times, with aircraft launched and recovered from either land or boat. All flights could be conducted below the 400 feet floor for navigable airspace, at altitudes between 80 and 120 m. The UAS could collect imagery with spatial resolution of between 2 and 4 cm per pixel, rendering it useless for determining a person's identity through facial features. Sequential surveys could provide details on human use patterns over the course of a day, allowing NPS staff to identify high use areas and locations that require management intervention. These survey data, coupled with the traditional survey techniques referenced above, would substantially improve the NPS's

understanding of how visitors actually use the park and how to better accommodate these uses.

Of course, surveilling people as they use a public resource raises concerns about individual privacy and personal security that should be addressed before initializing a UAS survey for any public land. For purposes of assessing the potential for legal liability on the part of the UAS operator, the threshold question is whether the researchers would be considered government actors. Our assumption here is that the research would be funded by a private grant for academic purposes. Although a use permit would be required for deployment of UAS over the park's boundaries, the work would not be the subject of a government contract. Consequently, the researchers in our hypothetical situation would not be considered to be government actors or agents.

Similar to the evaluation of a potential survey of recreational fishing effort, if the Duke University MaRRS Lab were to undertake this kind of UAS survey of Cape Lookout National Seashore, it would be prudent to evaluate the following legal considerations:

(a) a visitor's expectation of privacy while on park lands;

(b) curtilage doctrine application to tents and other enclosed spaces; and

(c) impacts attributed to the use of different imaging techniques.

A National Park Visitor's Expectation of Privacy

In the United States, citizens' concerns about their privacy have evolved over the years, and particular changes in the scope of those concerns have occurred in recent decades with the advent of digital technology and the Internet. Many have come to accept devices such as security cameras and traffic monitors as mundane facts of life. Indeed, " mass video surveillance occurs in the public realm – in streets, parks, and highways – [and] courts have been reluctant to find that individuals have reasonable expectations of privacy, at least in that information which they fail to conceal" (Blitz, 2004 , p. 1357). In fact, mass video surveillance is so pervasive that many courts have determined that even when used in the context of law enforcement, it does not amount to a " search" at all 55 .

Consequently, similar to the situation of the hypothetical survey of recreational fishing effort, visitors to national parks and other public lands have diminished expectations of – and rights to – privacy. Researchers would be acting within observed legal constraints when using aerial drones to study human use patterns within the boundaries of those public lands. As the Third Circuit has explained, the likelihood of a successful claim for invasion of privacy " is significantly [diminished, if] the surveillance is targeted at individuals in a public space, or even while on private property so long as they could be viewed from a public vantage point." 56

Although the basic observations of park use set forth in this hypothetical are unlikely to trigger legal liability, there are certain facts that could lead to concerns with particular variants of the " invasion of privacy" tort. For

example, if researchers publish recorded imagery that reveals identifying characteristics of an individual, there could be potential liability for the public disclosure of private fact or invasion of solitude/seclusion. The “ intrusion upon seclusion” tort turns on whether a reasonable person of ordinary sensibilities would be highly offended by such an invasion (see text footnote 35). This legal standard sets the bar rather high for a plaintiff, as most people – and thus the legally termed “ reasonable person” – generally would not have a high expectation of privacy in a public setting such as a National Park. Nevertheless, if the imagery captured an intimate detail of the person’s life that would cause an ordinary person to feel shame, anger, or embarrassment, liability could ensue.

Curtilage Doctrine and Tents

As set forth above in the discussion of curtilage doctrine and its application to fishing vessels, a visitor to a national park may be entitled to privacy protections in certain settings. If one is using a tent or trailer to camp within the boundaries of a national park, then the privacy protections attendant to a standard dwelling could apply. As discussed above, the courts generally protect one’s efforts to preserve privacy, even when occupying or moving about in a public space. Most tents and mobile campers are designed to provide a basic level of privacy sufficient to shield intimate behavior from scrutiny. While patterns of camping activity would likely be included in the uses of public lands that a researcher would be interested in recording, care should be taken to shield or exclude typically private behaviors from disclosure.

Alternative Imaging Techniques and Tracking of Individual Visitors

As discussed above in the context of potential research to quantify and characterize recreational fishing effort, using common and generally available recording technologies when deploying UAS would help minimize exposure to legal liability. At the same time, particular care should be taken to avoid collecting information that intrudes on the more intimate details of a person's life, especially within the confines of a relatively private enclosure such as a tent or privy.

While using new technologies to monitor private behavior could trigger legal liability, using new technologies to avoid disclosing private information could also protect researchers from liability. Around the time the *Boring* case was filed, Google took measures to address and alleviate some of the privacy concerns raised by its critics (Lavoie, 2009 , p. 614). The most significant action was to blur people's faces in the Street View images (Lavoie, 2009 , p. 614). Google also now provides a " takedown procedure" for images that are found to be offensive 57 . Takedown procedures are included in current (non-binding) " industry best practices." 58 Some academics recommend such " privacy by design" efforts (McNeal, 2014), and some government bodies actually require them 59 . Implementing privacy by design measures such as face-blurring, implementing proper take-down procedures, and setting up GPS-based " geofences" that limit the geographic scope of UAS-recorded images are threshold steps researchers can take to help avoid potential civil liability for invasion of privacy. In situations where sensitive data may be collected or archived, developing and adhering to a cybersecurity plan is essential. In these cases, restricting physical access to

the data can be augmented with strong encryption and access control lists designed to restrict access to only those that require it.

Conclusion

We conclude that – in most situations – researchers should be able to engage in drone-based surveys to assess recreational fishing and use of public protected lands by people for management purposes without fear of incurring legal liability related to the information gathered. As mentioned above, operational best practices can be applied to reduce legal liability and conform to governing regulations. For example, flights focused on estimating recreational fishing effort could be conducted with the camera locked facing downward for limited image collection. This approach would provide enough data to estimate effort across the study site, and at the same time reduce the likelihood of collecting sensitive personal information. Similarly, collecting imagery to estimate human usage of beaches around the National Seashore could be done obliquely from offshore and at a distance that would capture human usage patterns without flying over people or capturing their faces or other identifying characteristics.

However, there are two potentially important exceptions to that broad authority, one easily bypassed and the other largely unavoidable, both of which are reliant on a highly unlikely fact pattern.

First, using exotic alternative imaging techniques to monitor recreational fishers or park-users could make it more likely that researchers could potentially be alleged to have engaged in a privacy violation. As a result, specialized, niche imaging technologies like infrared and thermal should be

evaluated before use. By confining drones to more traditional imaging techniques, this potential complication could be mitigated. It is difficult to ascertain what sort of techniques now constitute “ exotic imaging” given the outdated case law and rapidly evolving technologies. Under these circumstances, if an advanced technology is necessary for project success, then an evaluation of the intrusiveness of that technology should be conducted and the results made available to involved parties.

Second, some state case law distinguishes open-topped boats from hunting and fishing venues that offer enclosures in which an individual might conduct private acts. It remains unclear what these threads of case law from other states could mean for North Carolina anglers whose vessels contain enclosed living spaces, or even just onboard heads. Unlike the Florida statute that explicitly states that boats are within the protected curtilage area, North Carolina does not at present closely define its curtilage doctrine. Further, Florida’s statutory policy relates specifically to boat curtilage in the context of breaking and entering and other crimes tied to physically invading an individual’s private spaces. Since researchers would not be conducting activities that could be construed as physical invasions of private space, they would have an additional layer of protection against a claim for “ invasion of privacy.” Additionally, any individual pursuing a potential suit would need to show that the use of drones actually violated her expectation of privacy while concealed within a vessel’s enclosures, and that that violation was highly offensive.

Finally, while UAS operators should feel comfortable engaging in basic color drone imaging of human activities in North Carolina’s estuarine and coastal ecosystems, the innovative nature of drones leads to uncertain conclusions regarding the Fourth Amendment. Considering the under-developed state of established law with respect to drones and privacy, it would be prudent for researchers to consider steps to protect themselves in advance of potential emerging questions. For particularly sensitive issues, it could be beneficial to approach the relevant state Attorney General to ask for a formal legal opinion on the matter, particularly with respect to the potential privacy issues involved. This procedure would increase transparency, help to avoid potential legal problems in the future, and create a degree of legal certainty that would otherwise be lacking. In addition, such an approach would help minimize the possibility that the UAS operator could be brought into a test case. Researchers also could request that their government contracts include explicit provisions holding them harmless in case of any alleged privacy violations. Public outreach and education about the drones themselves and the ways in which they are being used could assist in ameliorating public concerns and should be a part of any “ best practices” approach to engaging in UAS surveying projects.

Author Contributions

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Footnotes

1. ^ Federal Aviation Administration [“ FAA”] Modernization Act of 2018, Subtitle B, codified at 49 U. S. C. § 4480(c).
2. ^ Specifically, in 14 C. F. R. § 107. 39 (2016), Operations Over Human Beings, the term “ over” refers to the flight of a drone directly over any part of a person, from their head to their toes. Furthermore, § 107. 39 indicates that “ direct participation” refers to people who are involved with the flight operation of the drone, including piloting, acting as a visual observer, or otherwise acting to ensure the safety of operations.
3. ^ “ A robot’s operating requirements mean that even in the course of regular operations, it is gathering and storing information about everything that crosses its path. This gives robots an advantage over human operated planes, where a conscious decision to acquire and store data must be made.”
4. ^ 81 Fed. Reg. 42063, 42190 (June 28, 2016).

5. ^ See *Electronic Privacy Information Center v FAA* , 892 F. 3d 1249 (D. C. Cir. 2018).
6. ^ " Between 2013 and 2016, every state with the exception of South Dakota has considered legislation on drone use" (Farber, 2017 , pp. 374–375). As of May 2017, 135 local governments and 31 states had enacted some sort of rules governing drone usage (Vanian, 2017).
7. ^ The definition of " image" includes recording of thermal, infrared, sound waves, odor and other physical phenomena. Fla. Stat. § 934. 50(2)(b) (2018).
8. ^ Fla. Stat. § 934. 50 (2018).
9. ^ N. C. Gen. Stat. § 14-401. 25 (2018).
10. ^ N. C. Gen. Stat. § 15A-300. 1(b)(1)(a), (b) (2018).
11. ^ See, e. g., *Boring v. Google Inc* ., 362 Fed. Appx. 273 (3rd Cir. 2010) (holding that even if Google trespassed on a private road, which was marked with " No Trespassing" signs, to capture images of Plaintiff's residence, which it then uploaded onto Google Street View, Google's actions would not be highly offensive to a person of ordinary sensibilities and thus there was no invasion of privacy. The court also dismissed plaintiff's claims of negligence and conversion).
12. ^ U. S. Const. Amend. IV.
13. ^ *Marshall v. Barlows, Inc.* , 436 U. S. 307, 312 (1978).
14. ^ See *The Civil Rights Cases* , 109 U. S. 3 (1883); Gardbaum (2003) .
15. ^ See *Reitman v. Mulkey* , 387 U. S. 369 (1967).

16. ^ *Walter v. United States* , 477 U. S. 649, 662 (1980); see also Gardbaum (2003) .

17. ^ *Kyllo v. U. S.* , 533 U. S. 27, n. 1 (2001).

18. ^ It was important to the court that the photographer used a conventional commercially available camera commonly used in mapmaking and not a unique, highly specialized device. Moreover, the Court stated that even through the camera " enhanced" human vision, the photographs were not so revealing of intimate details as to raise constitutional concerns. *Dow Chemical v. U. S.* , 476 U. S. 227, 237–238 (1986).

19. ^ Id. at 235, citing *Oliver v. United States* , 466 U. S. 170 (1984).

20. ^ *Jones v. U. S.* , 565 U. S. 400 (2012).

21. ^ Id. at 405-406 and footnotes 5, 7.

22. ^ *Katz v. United States* , 389 U. S. 347 (1967).

23. ^ Id. at 361, J. Harlan concurring.

24. ^ *Donovan v. Dewey* , 452 U. S. 594 (1981).

25. ^ *Florida v. Jardines* , 569 U. S. 1 (2013).

26. ^ Id.

27. ^ *Collins v. VA* , 138 S. Ct. 1663, 1670 (2018).

28. ^ *California v. Ciraolo* , 476 U. S. 207 (1986).

29. ^ *Florida v. Riley* , 488 U. S. 445, 449 (1989).

30. ^ *U. S. v. Robinson* 62 F. 3d 1325, 1330 (11th Cir. 1995); *U. S. v. Pinson* , 24 F. 3d 1056, 1058 (8th Cir. 1994); *U. S. v Myers* , 46 F. 3d 668, 670 (7th Cir. 1995).

31. ^ *Kyllo v. U. S.* at 35.

32. ^ Id. at 28.

33. ^ *Katz v. U. S.* at 351.

34. ^ Restatement (Second) Of Torts §§ 652A–E (1997).

35. ^ Restatement (Second) Of Torts § 652B.

36. ^ Restatement (Second) Of Torts § 652B cmt. D.

37. ^ But see generally *Miller v. National Broadcasting Co* ., 187 Cal. App. 3d 1463 (Cal. Ct. App. 1986) (finding that a one-time videotaping of a man in his home while being resuscitated after having suffered a heart seizure was an invasion of solitude); *Nader v. General Motors Corp* ., 25 N. Y. 2d 560, 570 (1970) (finding that a single-time surveillance of a plaintiff in bank in an " overzealous" manner was an invasion of solitude). The key in these single-incident cases that distinguished them from the general rule was the degree of offensiveness that accompanied an inherently private action (medical and financial services).

38. ^ Restatement (Second) Of Torts § 652D.

39. ^ 15A N. C. Admin Code 031. 0113 (2019).

40. ^ *People v. Maikhio* , 253 P. 3d 247, 262 (Cal. 2011).

41. ^ The United States Court of Appeals for the Sixth Circuit has jurisdiction over federal appeals arising from the states of Kentucky, Michigan, Ohio, and Tennessee.

42. ^ *Hamilton v. Myers* , 281 F. 3d 520, 532 (6th Cir. 2002).

43. ^ *State v. Boyer* , 42 P. 3d 771, 776 (Mont. 2002).

44. ^ Id. Courts also emphasize the crippling enforcement difficulties that state agencies face in trying to sustainably manage fisheries and

hunting grounds, as well as the magnitude of the state's interest in enforcing fish and game laws (see Kuh, 2015 , pp. 32–37).

45. ^ *California v. Ciraolo* , 476 U. S. at 214.

46. ^ See *Oliver v. United States* , 466 U. S. 170 (1984).

47. ^ The United States Court of Appeals for the Third Circuit has jurisdiction over federal appeals arising from the states of Pennsylvania, New Jersey, Delaware, and the U. S. Virgin Islands.

48. ^ See *Boring v. Google, Inc.* , 362 Fed. Appx. 273 (3rd Cir. 2010).

49. ^ *U. S. v. Ellison* , 462 F. 3d 557, 563 (2006).

50. ^ *Katz v. U. S.* at 351, n. 9.

51. ^ See discussion supra p. 7; see also *Collins v. VA* and *Dow Chemical v. U. S* .

52. ^ N. C. Gen. Stat. § 15A-300. 1(b)(1)(a).

53. ^ Fla. Stat. § 810. 011(2), (3) (2017).

54. ^ See *Kyllo v. U. S.*

55. ^ Id., citing Slobogin (2002 , 236 n. 106) (listing fourteen cases that hold that public surveillance is not a search because any expectation of privacy would be unreasonable).

56. ^ *Boring v. Google* , 362 Fed. Appx. 279-80.

57. ^ Google Street View and Image Acceptance and Privacy Policies (2018) .

58. ^ See Voluntary Best Practices for UAA Privacy, Transparency, and Accountability, National Telecommunications and Information Administration [NTIA] (2016) .

59. ^ See European Union General Data Protection Regulation (2016) .

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