2013 & 2014 UAS Seabird Survey Test Flights Draft Report

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BACKGROUND

The goal of this pilot project was to test Unmanned Aircraft Systems (UAS) as a proof-of-concept tool for monitoring surface-nesting seabird colonies within the Washington Islands NWRs and Olympic Coast National Marine Sanctuary (OCNMS). Objectives are:

- Determine degree of disturbance to wildlife
- Evaluate quality of video and still frame photographs
- Assess capacity to collect overlapping, sequential still frame shots

This remote wilderness coastline in Washington State is difficult to survey and yet these surveys are key to assessing annual seabird population indices and associated threats such as climate change and marine debris. The majority of Washington's breeding seabirds can be found on these refuges. However, given logistical constraints, increased safety concerns and funding shortfalls, the future is uncertain for this annual survey effort on all three refuges. One of the UAS (Puma) used in this study was flown in 2012 over the Channel Islands NMS and NP with no negative effects to breeding seabirds or marine mammals. During these flights, a few pelicans, cormorants and marine mammals showed a mild, alert response, but no stronger response was noted.   This project will allow for a more thorough assessment of wildlife response to UAS at varying survey altitudes as well as comparison of still frame and video quality from two types of UAS and still frame shots from traditional aerial survey methodology.

During the second year, an abbreviated mission allowed for an initial assessment of the capacity of the Puma to collect sequential still frame shots necessary for accurately counting surface nesting seabirds in large, dense colonies.   Overlapping, sequential photos assure that individuals will not be over- (double counting individuals in each shot) or under-counted (missing individuals in between shots).   Since the majority of the islands of interest are located greater than 0.4 miles from shore which is the operational limit of the Quadracopter and it must be launched from land, we could only evaluate the Puma. Yet even with an expanded operational limit, the majority of the islands are located directly off shore of the Olympic National Park Wilderness Area and the NPS currently does not allow UAS use in any NPS, and especially not in wilderness areas.

METHODOLOGY

UAS UNITS & METHODOLOGY – Seabird survey flights were flown by fully trained operators from June 16-30, 2013 and June 17-19, 2014. The operators were co-located with science staff who directed camera angle and zoom, monitored video footage and requested photos during noncritical phases of flight. NOAA maintained full operational control of the units at all time. The UAS was flown toward each island at an altitude above ground level (AGL) of 150m (~500') to within approximately 100m from the perimeter of each island. The UAS was gradually transitioned from a higher to lower AGL until wildlife response was noted or 200' AGL was reached. If response was noted, the AGL and/or distance from the island were increased until disturbance was no longer noted or flights around the island were postponed.

Flights during 2014 primarily focused on testing methodology on traditionally dense clusters of murres on target islands. Two different types of navigational patterns were tested: fixed point and point to point within a square delineated with navigation waypoints. Cliff face and island top colonies were targeted to determine if different approaches would be necessary for each. Wind speed and direction were also factored in as a means to reduce flight speed to better achieve overlapping shots.

Two UAS units were tested in this project: the Puma and Quadracopter. The Puma is a small fixed-wing version of UAS owned and operated by NOAA. Like most UAS, the Puma was designed to emit minimal noise. During recent test flights, the Puma was undetectable to multiple sound meters beyond 30' AGL except on takeoff when a range of 68-85 dBA was detected. The Puma is equipped with a camera that is a proprietary design by the UAS manufacturer AV. The EO camera is 5 megapixels with a 31.5 degree field of view and transmits video at 30 fps at a resolution of 640x480 pixels. The IR camera has a 24.6 degree field of view and transmits video at 30 fps at a resolution of 640x480 pixels. The battery capacity will allow for 1.5 hours of flight time. With 4 batteries available, up to 6 hours of flight time is possible in one day. For more information go to: http://www.avinc.com/uas/small_uas/puma/.

The Puma cannot operate in winds greater than 25 knots. In addition, rain can impede the air speed indicator portal which will effect navigation. Optimum speed ranges from 20-40 knots, however a head or tail wind can increase or decrease speeds considerably. FAA restrictions require that the Puma remain within 1 mile of the pilot and within sight at all times. For inshore operations the FAA also requires the cloud ceiling to be >1,000' and visibility > 3 miles. If the unit is to be landed on the water, the sea state must be calm enough for landing (less than 15 knots wind, swell less than 4-6' and period of 12 seconds or more) which can vary depending on boat dynamics & availability of a lee behind an island. The Puma team was primarily located onboard the S/V Tatoosh. Vessel restrictions include no more than 10 people near shore and no more than 6 people offshore. It can cruise at approximately 24 knots with a limit of 25 knots of wind with 6 foot swells under ten seconds.

The Quadracopter (Md4 – 1000) is a small helicopter version of UAS. Optics on the Quadracopter provide a higher video quality with a 24 mega pixel camera when compared to the Puma but it must be launched from land. The distance in which the download link is effective essentially limits the range of the unit to 720m or 0.4 miles from ground operations. The camera can be operated in still or video mode but not both. Flight times range from 10-15 minutes followed by 40 minutes to 3 hours to recharge the battery. Flight speed ranges from 20-40 knots however; at only 12 pounds winds buffeted the Quadracopter quite a bit causing the video footage to be jumpy. The unit operates effectively at 12 knots of wind with a maximum of 20 knots. FAA restrictions require that the Quadracopter remain within 0.5 miles of the operator and maintain an altitude of 300' AGL or lower. In addition, pilots must have >1,000' ceiling and over 3 miles of visibility to operate the Quadracopter. This battery-powered unit emits less than 68 dBA of sound hovering at 3 meters AGL. This sound rapidly becomes imperceptible above 3m AGL. In addition, downdraft is negligible causing no movement of grass directly below the Quadracopter hovering at 2 meters AGL. For more information, go to: http://microdrones.com/products/md4-1000/md4-1000-key-information.php.

WILDLIFE RESPONSE - Trained seabird and marine mammal observers monitored wildlife behavioral response to the UAS with binoculars and a dedicated monitor for science staff located on site with the pilot. Behaviors in response to disturbance in seabirds include:

1. Mild - *Alert* – individual on the colony standing in an alert up-right posture, typically observing the disturbance or *Dive* - individual foraging in open water suddenly dives under water. Signifies an acceptable response to disturbance from non-listed species and is difficult to distinguish from disturbance definitively.

2. Moderate - *Preparation for flight/dive* - individual on the colony exhibiting wing lift or head bob behaviors or movement off the nest. Should trigger a change in altitude or movement away from the colony.

3. Severe - *Flush* - individual flushes off the colony rock or nest. Immediate response is necessary from the UAS or the entire colony may flush. Should return another day or later in the day to let birds settle back down.

Behaviors in response to disturbance in marine mammals include:

1. Mild – *Alert* - shifts in the animal's resting state or attention to an alert response while hauled out on land (lifting of head presumably to investigate the disturbance source more thoroughly), or changing orientation in response to the disturbance. An acceptable response to disturbance.

2. Moderate – *Vocalization* - may indicate increased levels of disturbance. Should trigger a change in altitude or movement away from the haul out.

3. High – *Dive/Flush* - flight response is a more dramatic change in ongoing behavior, and for marine mammals on land this typically means diving into the water. Immediate response is necessary from the UAS. Should return another day or later in the day to let them settle back down.

4. Severe – *Stampede* - panicked movement and stampeding may occur from a marine mammal haul out site. Immediate response is necessary from the UAS or the entire haul out may vacate. Should return another day or later in the day to let them settle back down.

Special considerations for Marbled Murrelets – This species forages at sea within the study area. In addition, there are approximately 8 historic nest sites (as indicated by occupied behaviors) within one mile of the coastline. In order to avoid disturbance to this federally listed species, we scanned the area around the boat prior to launch and landing to look for murrelets on the water. If murrelets were observed in the immediate area we moved to another location or flew surveys another day.

Special considerations for Sea Otters - Sea Otters will respond to a potential disturbance at a greater distance than most other marine mammals. An alert response, with head up watching the disturbance typically precedes a dive or, in some cases the group will 'stampede' away from the source of disturbance. Given the prevalence of this species throughout the area and potential to fly over otters in transit to other seabird colonies, we tested the response of a group of otters to the UAS from 500' to 350' AGL in the early stages of the project. We avoided areas that support large rafts known to show a more severe response to disturbance (i.e. group off Destruction Island).

IMAGE QUALITY - All video footage was saved digitally to preserve quality on two 2TB external hard drives. All files include a telemetry log tied to the video with flight speed and altitude tied to location. An mpeg with telemetry and timestamp data embedded in the video and a csv file which will show the same flight parameters in text format were created for each flight segment. The telemetry file can be converted to a KML file of the UAS track for GIS. Full resolution still images were also taken while in flight. This process reduced video quality for approximately 20 seconds as the downlink uses bandwidth to send the full resolution image. Raw still images were transmitted as a NTIF file which is georeferenced. These were then also converted to JPEG format.

During post processing, we assessed the video resolution to determine if it was sufficient to survey seabird colonies by comparing the quality of video footage and still shots captured by the UAS to the quality of photos collected following the conventional USFWS-WMNWRC survey methodology. Image quality must be sufficiently high enough so that nesting materials are clearly visible because only gulls or cormorants on nests are counted in the Surface-nesting Seabird Survey. In addition, all Common Murres on the colony must be counted which is often difficult due to high density and micro topography (e.g. birds under ledges or in deep shadow). Often, only the clearest close up still frame shots can be counted.

STUDY AREA

Islands targeted for UAS test flights include:

Island Name	Approx Elevation (ft)	Refuge	Latitude	Longitude	2013 Target	2014 Target
Grenville Arch Rock	88	C	47.296111	-124.283056	√	
Erin's Bride	100	C	47.299167	-124.266944	√	

Erin	100	C	47.300278	-124.266667	√	
Grenville Pillar	80	C	47.302222	-124.279167	√	
Split Rock	70	C	47.408056	-124.362778	√	
Willoughby Rock	120	C	47.411667	-124.354722	√	
Destruction Island	90	QN	47.676667	-124.482500	√	
Table Rock	120	QN	47.881111	-124.635000	√	√
Huntington Island	100	QN	47.883889	-124.637500	√	√
Cakesosta	100	QN	47.883889	-124.635278	√	√
Gunsight Rock	180	QN	47.908056	-124.650556	√	
Petrel Island	180	QN	47.910556	-124.650000	√	
Cake Rock	116	QN	47.932778	-124.683889	√	
Jagged Island	320	QN	47.996667	-124.694444	√	√
Carroll Island	225	QN	48.005556	-124.721111	√	√
Carroll Pillar	200	QN	48.006944	-124.724167	√	
White Rock	162	FR	48.134722	-124.733333	√	√
Bodelteh Island West	150	FR	48.175833	-124.762222	√	√
Tatoosh Island	140	NA	48.392222	-124.735278	√	

C – Copalis NWR, QN – Quillayute Needles NWR, FR = Flattery Rocks NWR, NA = Not applicable

RESULTS

UAS UNITS & METHODOLOGY - The study was completed in 2013 with approximately 11.9 flight hours on the Puma and 1.5 flight hours on the Quadracopter. The Puma was launched and recovered primarily from the OCNMS R/V Tatoosh around all refuge islands listed above except for Destruction Island, Split and Willoughby Rocks. Flights around these islands were canceled due to mechanical issues with the R/V Tatoosh. The Puma was also launched from land at Point Grenville, but the flight was canceled due to heavy fog. The Quadracopter was launched and recovered from tribal lands at Point Grenville and First Beach, La Push. Approximately 3 flight hours were flown on the Puma in 2014. Test flights were flown around all target islands.

Due to a high minimum flight speed and essentially slower manual control of the camera angle in conjunction with high updrafts or tail winds, it does not appear possible to collect overlapping, sequential still frame shots with the Puma at this time.

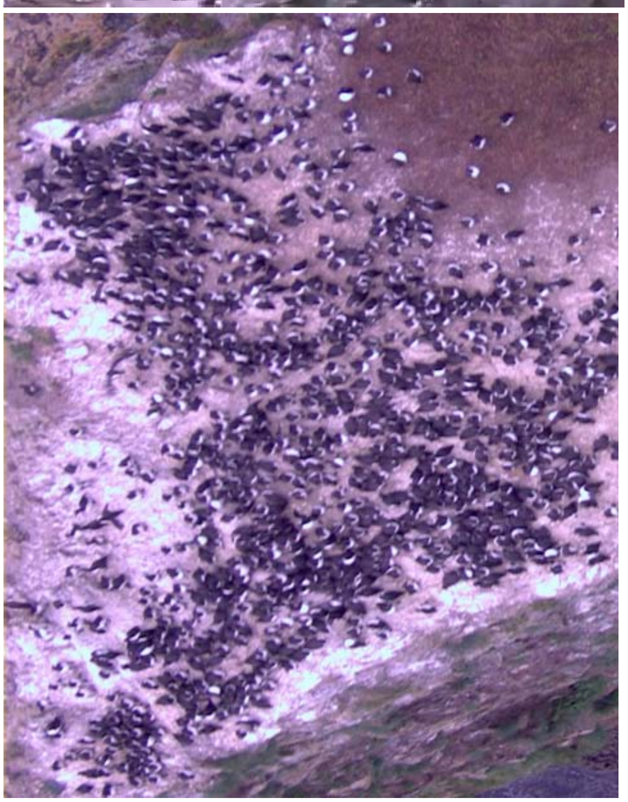
WILDLIFE RESPONSE –Very little wildlife disturbance was noted through careful observation from both the boat and video monitor while the units were in flight. Species observed include Brandt's, Pelagic and Double-crested Cormorant, Common Murre, Tufted Puffin, Western/Glaucous-winged gull hybrid, Pigeon Guillemot, Brown Pelican, Common Loon and Black Oystercatcher. No Marbled Murrelets were observed prior to launch or while in flight. Seabird response was minimal with a few mild, alert behaviors observed in cormorants and murres at the lowest level of flight (200' AGL) for the Puma. A few murres flushed from Jagged

Island during a Puma flight in 2013, but we were unable to determine if the response was directed toward two eagles in flight as well. In fact, more often murres were observed landing on the island while the Puma was on transect. Overall, a similar response was noted in seabirds to the Quadracopter in 2013. However, one incidence occurred in which a small number of pelicans, cormorants and murres flushed from Erin Island when winds buffeted the Quadracopter below 200' AGL. The flight was stopped, but resumed an hour later with only mild signs of disturbance (alert posture) at the lowest altitudes (>200' AGL). Marine mammals showed a similar response. A raft of approximately 75 otters was observed on the second day of the study in 2013. No signs of disturbance were noted in the otters with the Puma in flight as low as 350' AGL. Some mild, alert posturing was noted in marine mammals on Sea Lion Rock in 2013 during a Puma over flight at 400'; however this may have been due to male territorial posturing observed at the time. Marine mammals observed during flights include Northern Sea Otter, Steller and California Sea Lion and Harbor Seal.

No disturbance was noted in seabirds or marine mammals during reduce operations in 2014 in response to the UAS. The unit did capture limited footage of a colony-wide flush in response to an eagle approach and capture of an adult Common Murre. This colony was vacated the day before during the traditional aerial survey and we suspect the local eagle pair were working the colony for days. This effectively ended operations at this archipelago however it should be noted, that even during a period of ostensibly heightened vigilance; murres did not flush in response to the UAS while in flight over the colony for 20 minutes prior to this incidence of predation.

IMAGE QUALITY - Due to bandwidth limitations in the downlink, the avionics compress the video down from the 5 MP resolution. Additional image quality was lost while converting from a mpg to a mov format for VARS (Video Annotation Reference System; used by OCNMS to analyze underwater footage). As a result, the image quality was reduced to such an extent that counting birds using the still frame or video footage was not possible. Also, since the current footage/software does not have the capacity to zoom in, gulls or cormorants on the nest cannot be distinguished from those roosting nearby. Below are some still images that are comparable to the video footage for comparison of image quality.

Still frame grab from video footage in VARS taken during post processing (orig 5.94M prior to crop). Not countable.



Still frame from PUMA in flight (14.4M). Countable.

Still frame from Helo surveys (60.2M). Countable.

RECCOMMENDATIONS & DISCUSSION

UAS UNITS & METHODOLOGY - Ultimately, collecting overlapping, sequential still frame shots of high enough quality to count individual seabirds is the goal. The Puma provides a much better range and versatility of launch locations. However the slow speed of the downlink combined with faster flight speeds and occasional high tail winds render it currently unsuitable for our needs. Upgrading the payload to a high quality camera and improving the navigation software that can also direct the camera (24 MP or greater) to take sequential pictures without overlap would be idea. New GPS mapping software would enable the Quadracopter to take sequential still frame shots, particularly of the top of islands. However, due to restrictions on range (<0.4 mi) and launch location (land only) as well as instability in moderate winds, this unit is not currently suitable for this application. NOAA is developing protocols to enable operators to launch and land the Quadracopter from a ship, but a new camera, of similar quality to the current camera, will be necessary as the current camera is not waterproof. The Puma would be the preferred platform due to its long range and greater stability.

Next steps include:

- Conduct a cost comparison between traditional and UAS survey platforms (before we can continue field testing)
- Improve in camera technology (governed by the UAS manufacturer) and navigation software.
- Test methodologies with new technologies

- Compare photographs and results among platforms (e.g. helicopter, Puma and/or Quadracopter) & determine if a correction factor is needed to maintain continuity in data.

This will allow for a more seamless transition from helicopter to UAS as a survey platform while maintaining data standards across two states and 4 Refuges.

VARS was originally identified as the video editing software for this project in an effort to incorporate bird survey data seamlessly into the OCNMS biological survey data. Since VARS was designed to process underwater video footage and the data standard for surface nesting seabird surveys is still frame shots processed in a geospatial database, use of VARS and collection of video footage is optional for this mission unless funding is provided by other partners. If video footage is identified as a product for others, a more efficient video editing software or significant improvements to VARS along with a computer system designed to handle large video files are necessary.

WILDLIFE RESPONSE – Given that no to minimal disturbance was noted in response to the units above the lowest altitude tested (200’ AGL) this remains the recommended lowest limit for flights around seabird colonies. Altitudes in transit should remain above 350’ AGL in this area as Sea Otters can be found virtually anywhere within this study area and they have not shown any signs of disturbance in response to the Puma at 350’ AGL. Since the majority of wildlife response, or lack thereof, was tested using the Puma, further testing should be conducted with the Quadracopter to confirm these recommended altitudes.

IMAGE QUALITY - Ultimately any imagery must be of high enough quality to zoom in and count murres in dense clusters often found in areas of varying micro topography or under ledges. Still frame shots processed in a geodatabase remain the data standard for the surface nesting seabird survey and the best option to count such dense, complicated clusters. Video is much too fast and choppy and does not yet provide the quality of imagery to either pause or take still frame grabs for counting.

In addition, imagery must be of high enough quality to zoom in to and differentiate between different types of nest materials for identification and counting of cormorants. Only cormorants and gulls on nests are counted and often the difference between two (one of high conservation concern and another proposed for population management) is the type of nesting material.

Additional factors affect image quality including camera settings and environmental conditions. While the camera autocorrects exposure, light levels significantly change from frame to frame which further reduces image quality. Also, either environmental conditions on hazy, humid days reduce image quality or condensation on the lens obscures the image. Issues associated with image quality and ability to manipulate photos (e.g. zoom, sharpen, contrast, and brighten) for counting may be resolved with different software and camera systems while those associated with environmental conditions can be mitigated by following appropriate protocols.

INCIDENTAL OBSERVATIONS - IR scans appear to be useful for marine mammals but birds are too small to be readily visible. IR scans would be effective in spot checking for marine mammals, particularly early in the day before rocks have begun to heat up. The current methodology for conducting Sea Otter surveys remains the most effective largely because observers in a fixed-wing aircraft have a much wider area to scan and more control over that scan. That said, the most effective methodology for large area scans using the UAS would follow those for off shore marine debris. Specifically conducting a slow but systematic side to side scan while flying the transect. Roughly 400' AGL equates to a 200' wide transect line. Combining transects with wide angle shots of nearby coastline would be helpful in maintaining perspective for navigation and detection. A balance between scan speed for real time scans vs. video processing for surveys is important. Consider upgrading navigation software to allow for sequential transects of an area rather than the point or box pattern currently available.

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