UAV-Based Imagery Prospects for Dolphin Detection: Q&A Between St. Andrews University Professor Stephen Buckland and Brainlike, Inc. CEO Bob Jannarone

Shared at the IATTC Workshop on Methods for Monitoring the Status of Eastern Tropical Pacific Ocean Dolphin Populations

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(Questions and comments by Professor Buckland are set in **bold, blue font** below. Responses by Bob Jannarone are set in red font below.)

For the workshop, we're trying to identify the most cost-effective way of estimating abundance of dolphin stocks targeted by tuna purse seiners. Past surveys were done by observer teams on board research vessels, and there is a view that future surveys should be designed to be comparable with those. My own view is that in future, such surveys will be done using high-resolution imagery from drones. Software to identify objects in the images then becomes key, so I think your input could be invaluable. Issues to be discussed include:

1. **Is it feasible with currently-available drones to survey the ETP without having to fly the drones from a ship? Thus drones will need to be able to travel large distances from one island to another – or from one island and back. It is not possible to cover these distances if restricted to daylight hours, so the drones would have to continue through the night.**

We could research currently available and affordable long-range options. I know of similar options that have been considered for the Arctic Sea and the Gobi desert. Having some sense for ship-based observer cost and coverage could help us scope options that could produce more coverage at lower overall cost. Launching the drones from a ship that is using observer teams might make sense for openers. Doing so would enable us to evaluate drone-based capability of identifying the same dolphins that observers have identified, as well as additional dolphins that the observers have not identified.

2. **To avoid the need for experts to search through large numbers of images, we need software to locate objects.**

Software is available to locate objects, but perhaps more importantly to exclude images and image regions from further inspection. When compared to experts searching through images very carefully, the software will miss some dolphins that the experts locate, but the software will substantially reduce analysis effort. A dolphin-based detection rate versus analysis effort pilot evaluation could help determine software versus expert detection value. Even without software, expert observation of drone-based video could produce substantial improvements in coverage and detection rates, relative to ship-based observation, while reducing on-board observer costs and risks. Again, a pilot evaluation could be useful. Affordable pilot evaluation results could speed decisions to deploy cost-reducing software and/or drones if the evaluations show dramatic improvements. The evaluations could also reduce risks of making costly investments in software and/or drone deployments that would produce poor results.

3. **Once located, objects need to be identified; this could be done by experts if the above software has reduced the number of images to an acceptable number, or it too might be done using software.**

Software-based reduction of images to an acceptable number is always possible, but configuring the software to do so while ensuring that only a small percentage has been missed is always a challenge. How well that challenge can be met is an empirical question, best answered by an evaluation study. Our experience has shown that analysts must always be in the loop, especially for precise species classification and counting. Software can greatly reduce the images (and sub-images) containing dolphins, but human eyes on the reduced images will be necessary. We may find that the brunt of analysis can be affordably performed by trained observers without advanced degrees in ways that will further reduce staffing costs.

4. **There needs to be an assessment of whether schools within the survey strip are missed, and if so, what is the probability of detection. (The target species tend to form medium to large schools, so that some animals will always be at the surface.**

In order to make that assessment precisely, we will need validation data, obtained from ship-based observers or other sensors (perhaps sonar or infra-red sensors or tagged dolphins). No way around it.

5. **Can school size be reliably estimated from the images?**

Perhaps. Software could be used to detect school features (such as white-water turbulence) at the pixel level, then edge detection could be used to estimate perimeter points, then the perimeter points could be used to establish the perimeter border, and then the dolphins within the perimeter border could be counted. Powerful, cloud-based computers would probably be necessary. Uploading huge datasets containing raw images to the cloud could be a problem. Uploading only images or sub-images that have been triaged beforehand might be better. Having analysts instead of software count the dolphins from triaged sub-images might be best. Doing so might also be affordable, since volunteers are increasingly on hand to help via social media.

6. **How do costs compare with shipboard surveys?**

We could work that out, along the lines of the following desert tortoise scenario that we are working. Clark County biologists spend six-figures annually to have observers walk through fields looking for desert tortoise. Walk-throughs are structured to produce as much coverage as possible (10m swaths), while observers look left and right. Required plot coverage takes several observer-months every year. Observer detection rates are less than 20%, based on tagged tortoise validation. A drone can cover ten times as much land in two flight days at a data-gathering cost of about $15k and an altitude of about 50m. A pilot study is being designed that will evaluate precision of ground-based detection, relative to precision of drone/observer-based detection, with and without software. Drone/observer-based detection could win the precision contest, even with detection rates lower than ground-based detection, because ground-based detection covers less territory. If drone/observer-based detection wins the precision contest, then it will also wind up costing much less. However, that's a big "if" that must be determined. Desert tortoise are very tough to detect from the air (unless you're a predatory raven). We could design a similar scenario for detecting dolphins from the air. It's tempting to say that dolphin detection could be easier than tortoise detection, but experience has shown that sensor-based event detection is **never** easy.