Exploring the white ribbon with impeller-driven kayaks.

Phil Anderson

Scottish Association for Marine Science

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Gaining measurement access to the ca. 1 km wide 'white ribbon' of coastal waters is problematic: to shallow for large ships, to deep for waders. Autonomous kayaks can bridge the gap and are now relatively simple to build and operate.

The open source avionics package of "Pixhawk" hardware running the "ArduPilot" family of software is now available in a form for small boats, and a viable platform can be built as a student robotics project or for a bespoke sensor requirement.

SAMS has small but growing number the these Impeller-driven kayaks ("ImpYaks") and at present cover:-

sea-surface weather
underwater camera
through hull ocean colour spectroscopy
ADCP flow profiles
noctural bat monitor

Two factors of the robotics platform enhance data gathering with this system. Firstly accurate surveys can be designed and uploaded to the craft in a few minutes, and even when the craft is under way. Telemetry data giving live feedback on the mission, akin to how UAV surveys are conducted, and positional accuracy is 10cm or better. This generated better survey coverage and data are geolocated automatically.

A second use is the 'Loiter' function, where the avionics maintain the craft geo-stationary, and therefore acting as an instant surface mooring. The craft can be left overnight in one spot, given sufficient battery.

The presentation will give a few snapshots of data from the units and an opportunity for the MASTS community to suggest additional areas for the ImpYak to make an impact.

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Robotic kayaks offer a cheap platform to get pre-programmed surveys within the problematic near shore sea. Open source avionics make such systems relatively cheap with a large support community. sea-surface weather, ocean colour and ADCP are a few of the instruments deployed.

The full abstract should be submitted to masts@st-andrews.ac.uk, in an editable format, by 16:00 Friday 14th August 2020.

Abstract authors who are selected to give a 5-6 minute flash-talk at the ASM will also be asked to provide a 30-60 second pre-recorded video abstract of their talk for promotional purposes.

The title should be typed in font Arial 14 pt bold.

The Authors' names should be typed in Arial 9 pt, with the presenting Author underlined.

The Authors' affiliations should be typed in Arial 8 pt italics. The email address of the presenting Author is requested, and he/she will be referred to also as the Corresponding Author.

The main text should be typed in Times New Roman 10 pt.

A brief paragraph with acknowledgements may be added at the end of the main text.

A limited number of citations in the text are allowed, and the relevant list of references should be added at the end of the abstract. The references should be typed in Times New Roman 9 pt.

For consistency, please do not exceed one page in this format.

Acknowledgements

All the Authors are kindly thanked for having submitted an abstract formatted according to this template.

References

Authors (Year). Title. Journal title, number (issue) and page numbers.

Estimating and accounting for fish losses under the footrope of a survey trawl: the case of northern shelf anglerfish

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Tweetable Abstract:
"How many fish escape under the net? The capture efficiency of trawling gear may be investigated using collection bags located beneath the footrope to account for fish that would otherwise be lost." #MASTSasm2020.

Monkfish, or anglerfish, (*Lophius piscatorius* and *L. budegassa*) are two of the most valuable commercial fish species in northern Europe. The stock which occupies the northern European shelf is monitored by an annual bottom trawl survey which aims to estimate absolute abundance (Fernandes *et al*., 2007). This estimation includes corrections for herding by the trawl gear but also requires an estimate of the capture efficiency of the net (Reid *et al*., 2007). In this study, the component of catch efficiency corresponding to escapement of fish under the footrope is estimated. Losses of fish [at length] under the footrope were quantified using trawls fitted with sub-footrope collection bags. Scale models were tested in flume tanks to refine the design of the collection bags and the gear performance during the survey was monitored to ensure that it was not significantly affected by the modifications. The results demonstrate clear length dependency with the smallest fish being the most likely to escape under the gear. Overall approximately 27% of the anglerfish were lost under the footrope, with approximately 77% of those below 30 cm being found in the ground gear collection bags. The length-based retention curve for the gear was fitted here with a day-night effect, following appropriate model selection. This produced higher proportions of fish escapes at night than during the day. The resulting selectivity function was then applied to the existing annual monkfish survey to examine its impact on the stock estimates. A significant increase in the stock abundance was demonstrated, particularly for smaller fish, when escapement under the footrope is accounted for. This provides an absolute abundance estimate which may be used as an indicator in the current anglerfish assessment.

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Fernandes, P. G., Armstrong, F., Burns, F., Copland, P., Davis, C., Graham, N., Harlay, X., O'Cuaig, M., Penny, I., Pout, A. C., and Clarke, E. D. (2007). Progress in estimating the absolute abundance of anglerfish on the European northern shelf from a trawl survey. ICES CM 2007/K:12. 14 pp.

Reid, D. G., Allen, V. J., Bova, D. J., Jones, E. G., Kynoch, R. J., Peach, K. J., Fernandes, P. G., and Turrell, W.R. (2007). Angler fish catchability for swept area abundance estimates in a new survey trawl. ICES Journal of Marine Science, 64(8): 1503–1511.

Autonomous underwater videography and tracking of basking sharks

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Please provide an additional tweetable abstract first (max. 280 characters) to assist online promotion. #MASTSasm2020: What do basking sharks do below the surface? Using autonomous underwater vehicles, we are gaining greater insight into basking #shark behavior at depths where they cannot be directly observed. @nature_scot @ExeterMarine @WHOI @wwf_uk
Twitter handle: @OwenExeter

Biologging studies have revealed a wealth of information about the spatio-temporal movements of marine vertebrates large enough to carry electronic tracking tags. Developments in animal borne cameras and autonomous underwater vehicles (AUVs) have now opened the possibility of using remote camera technologies to gain insight into the biotic and abiotic context (e.g. social environment, prey and predator presence) in which animals move. To minimise energetic impacts, animal borne cameras are often miniaturised, meaning that their battery life is usually reduced, and they can carry a limited number of environmental sensors. In comparison, AUVs can carry larger scientific payloads, and thus collect more sensor data, and because they can carry a larger payload of batteries, can often collect data for longer than animal borne cameras. These benefits have resulted in successful application of AUVs to gain novel insights into the ecology of, for example, leatherback turtles and great white sharks (Dodge et al., 2018, Skomal et al., 2015).

The basking shark (Cetorhinus maximus) is the second largest fish in the world and is endangered in the northeast Atlantic. Despite being subject to various biologging studies, little is known of this species breeding ecology and their mating grounds remain unknown. The present study is the first to successfully use an AUV to gain insight into the sub-surface behaviour of basking sharks. Using a REMUS-100 SharkCam, the project attempted to film courtship and mating by basking sharks in Scottish waters, as well as to gain a greater insight into basking shark behaviour sub-surface, at depths where they cannot be directly observed.

Three basking sharks were tracked for a cumulative total of 10.9 hours in the waters of the Inner Hebrides. Five AUV mounted cameras recorded near 360-degree views of tracked sharks' biotic and abiotic environment, whilst environmental sensors monitored surrounding conditions (current speed, chlorophyll, temperature and depth). Breeding or courtship behaviours were not observed, however the AUV revealed a greater than might be expected association with the seabed, a behaviour not routinely reported for a species regarded as a near-surface filter feeding shark. The AUV further provided a rich near-stereoscopic overview of fish movement with environmental context inaccessible by other technologies. These insights could directly influence assessments of putative threats for the species and subsequent management strategies.

Acknowledgements

The project is funded by WWF/Sky Ocean Rescue, Scottish Natural Heritage (SNH), Woods Hole Oceanographic Institution (WHOI) and the University of Exeter, with additional support from Sea World Busch Gardens Conservation Fund and Hydroid Inc. REMUS-100 SharkCam technology is owned and operated by WHOI. The authors thank the following boat operators, skippers and crew: Chris Jackson, Richard Darby, James Fairbairns, Iain Malcolm, Harry Mansfield and Rona McCann.

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Dodge, K. L., Kukulya, A. L., Burke, E. & Baumgartner, M. F. (2018). TurtleCam: A "Smart" Autonomous Underwater Vehicle for Investigating Behaviors and Habitats of Sea Turtles. Frontiers in Marine Science, 5, 90.

Skomal, G. B., Hoyos-Padilla, E. M., Kukulya, A. & Stokey, R. (2015). Subsurface observations of white shark Carcharodon carcharias predatory behaviour using an autonomous underwater vehicle. Journal of Fish Biology, 524 (87), 1293.

Snot and steroids: exploring steroid hormones in whale blow via UAV collection for physiological monitoring

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Monitoring physiological processes in cetaceans can inform species conservation, by reflecting individual fitness and population health. However, measuring parameters such as hormone concentrations is challenging in free-ranging cetaceans. Sample types often require invasive collection and measured hormone concentrations may not reflect short-term variability in circulating levels. As such, monitoring fine-scale responses of whales to disturbance requires consideration of novel sample types and collection methods.

Exhaled breath ('blow') may represent a suitable alternative. Blow can be collected unobtrusively via unoccupied aerial vehicle (UAV) and hormone concentrations respond rapidly and proportionately to changes in circulating levels. However, samples are small and variably diluted by environmental water, impeding hormone detection and quantitation. In large whales, hormones have only been detected in samples collected from a research vessel in close proximity, which may induce stress.

Here, we demonstrate the potential to combine unobtrusive, UAV-based collection with sensitive metabolite detection to explore steroid hormones in whale blow. Thirty-two samples were collected from humpback whales in North Iceland (2018-19), up to 2 km from the UAV pilot, with minimal observed behavioural response. Following storage at -20°C, samples were extracted from Petri dishes with a simple ethanol-water wash.

Steroid hormones were detected with reverse-phase liquid chromatography-mass spectrometry, allowing parallel quantitation of numerous metabolites. Fourteen samples were assayed: 2018 samples were screened for cortisol and 2019 samples were screened for 19 steroid hormones. Results indicate the presence of multiple steroids in blow collected by UAV, including cortisol (6/14), testosterone (3/9), progesterone (8/9) and DHEAS (4/9) – to our knowledge, the first published detection of this hormone in cetaceans.

Whilst further method development is necessary, these results demonstrate the potential to use blow samples for physiological assessment. Indeed, blow may be the only suitable sample type to assess both short- and long-term responses to environmental change. Further, this study highlights the importance of novel and diverse collaborations – here, between marine biologists and a clinical research facility – to monitor the health and status of marine life.

Acknowledgements

Thank you to the students and interns who contributed to sample collection: Danny Kosiba, Katy Maleta, Flordespina Dodds and Beverly Tan.

Tweetable abstract

@whalewiselive exploring steroid hormones in whale breath samples collected by UAV. A potential tool for stress assessments? #MASTSasm2020

Twitter handle: @whalewiselive

Sex-specific variation in the use of vertical habitat by a resident Antarctic top predator

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Patterns of marine vertebrate habitat use are commonly studied in horizontal space, but this does not capture the four-dimensional nature of ocean habitats (space, depth, time). Deep-diving marine animals in particular, encounter a range of oceanographic conditions. This is pronounced at the poles, where there is strong seasonal variation in vertical ocean structuring. The vertical dimension of space use is hidden if we only consider horizontal movement, and movement patterns with large variability in depth might be missed completely.

To identify different diving behaviours and usage patterns of vertically distributed habitat, we use hidden Markov models fitted to telemetry data from an air-breathing top predator, the Weddell seal, in the Weddell Sea, Antarctica.

We present evidence of overlapping use of high-density, continental shelf water masses by both sexes, as well as important differences in their preferences for different oceanographic conditions. Males spend more time in the unique high-salinity shelf water masses characteristic of sub-ice-shelf circulation and melting, while females also venture off the continental shelf and visit warmer, shallower water masses characteristic of input from the Antarctic Circumpolar Current. Both sexes exhibit a diurnal pattern in diving behaviour (deep in the day, shallow at night) that persists from austral late summer into winter. The differences in habitat use in this resident, sexually monomorphic Antarctic top predator suggest a different set of needs and constraints operating at the intraspecific level, not driven by body size.

Automatically identifying salmon farm characteristics using machine learning based classification of satellite images

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The man-made structures in and around open-pen salmon farms can be an important factor in better understanding disease or pathogen spread, fish welfare, and potentially other issues of management or regulatory interest. Information on these types of variable is typically not recorded in, say, fish health data sets. However, there are open source repositories of satellite images from which it should be possible to glean data on relevant characteristics. The present study used machine learning algorithms to interrogate such images with a view to gaining useful information regarding physical farm characteristics.

Historically many salmon farms used grids of square/rectangular pens, though over the past decade these have been increasingly replaced with circular pen structures. Looking through a series of satellite images captured over the past 20 years, two immediate and relatively simple tasks which seemed well-suited to machine learning approaches presented themselves. The first was to create an algorithm which could distinguish between farms consisting of square or circular pens, while the second was to then count the number of such pens that were present on a given site.

The primary source of satellite images used in this study was Google Maps due to the readily available sets of images that could be automatically accessed at scale using the *Google Maps Static* API. Images of farms from across Scotland were used in the initial algorithm training and test phase (using publicly available lat/long coordinates), while additional images of farms in Ireland and Canada were used to further test the accuracy of the algorithm. The initial algorithms were created using standard supervised classification approaches in *Scikit-learn* but a range of decision tree and regression based models were found to perform poorly. A Convolutional Neural Network (Mask R-CNN) based approach situated within the *Supervise.ly* platform was then explored and found to be highly effective.

Across the test sets there were almost no cases (out of ~200 farms) where the algorithm was not able to identify the difference between square and circular pen based farms. In terms of counting the numbers of round pens, the accuracy ranged from 93.5 - 97%, with false positive values ranging from 1.1 - 3%. As usual in any such classification, a trade-off existed between specificity and sensitivity. For example, it was possible to accurately count 100% of the Canadian circular pens, but this resulted in a higher false positive rate of ~10%.

This talk will present some of the challenges of using a machine learning approach for this type of task, including the main sources of error, the resolution of images required, etc.; as well as demonstrating the potential of using automated farm classification to augment longitudinal research studies.

Tweetable abstract: Algorithmic classification of images has become increasingly accurate over the past decade. Can these approaches allow machines to annotate satellite images of salmon farms to better inform models that predict disease outbreaks or pathogen spread?

Low-cost resource assessment for community scale tidal stream power generation

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Low-cost resource assessment for community scale tidal stream power generation

Emma Whettall[1]

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Tweet:
Instantaneous site-wide velocity estimates are derived from tracking surface flow features through consecutive images captured on off-the-shelf DSLR cameras. This novel methodology provides a low-cost, accessible alternative for early stage tidal stream site assessment. @EWhettall

There is an increasing interest in small scale tidal stream energy projects to decarbonize the energy supply of remote communities. Marine environments are famously complex and inflow instabilities are known to reduce turbine performance. Fully understanding a site's hydrodynamics is therefore paramount in order to ensure cost-effective device design, optimal placement and overall project success. This research presents a novel resource assessment methodology that explores the physical nature of the tidal resource, characterizing the spatial-temporal flow structure and variability in a way that is not achievable by more traditional techniques. Instantaneous site-wide surface velocities are derived from tracking surface flow structures captured by georectified DSLR images, in a technique adapted from digital particle image velocimetry traditionally employed in a laboratory setting. Results from a test case in Cuan Sound, a tidally energetic channel on the west coast of Scotland, are presented and validated against Lagrangian drifter measurements. High resolution velocity fields, cross axial velocity transects, and shear and vorticity calculations illustrate the potential of this new methodology for deeming a site suitable or unsuitable for tidal stream energy before considerable amounts of money and resources are invested.