## Machine Learning for Analyzing Data from ASL's Echosounders

ASL Environmental Sciences Inc. (ASL), University of Victoria, and the Department of Fisheries and Oceans (DFO) recently completed the first phase of a collaborative research initiative to develop automated analysis tools for data collected by ASL's multi-frequency echosounder, the AZFP (Acoustic Zooplankton Fish Profiler). This phase of the research was co-funded by ASL and the Natural Sciences and Engineering Research Council (NSERC) through Engage and Engage Plus Grants. The research project was led by Professor Alexandra Branzan Albu from the Electrical and Computer Engineering Department of the University of Victoria in collaboration with DFO and ASL experts.

The AZFP data for this research, along with expertise in the areas of fisheries acoustics and echogram interpretation were provided by Dr. Stéphane Gauthier of DFO. The AZFP provides high temporal and spatial resolution acoustic backscatter. Through this collaborative research, we focus on developing methods and systems to automatically classify backscatter from AZFP data. Dr. Albu and her team bring their expertise in computer vision and machine learning to help solve today's challenges in environmental monitoring with the ever-increasing data availability and the need for automation. Typically, AZFP data analyses rely on manual interpretation and visualization methods. The systems developed during the project aimed to automate techniques to remove background noise, select regions of interest, detect objects and classify them using several machine learning frameworks that range from conventional supervised learning using hand-crafted features, to end-to-end Deep Learning based object detection networks. As a use case, the study focused on schools of herring. Detection algorithms have been trained and tested on 358 echograms containing 745 schools of herring. Preliminary results were presented at the Machine Learning Workshop during the PICES 2019 Annual Meeting in Victoria, BC. and at a workshop entitled "Tackling Climate Change with Machine Learning" as part of the Conference on Neural Information Processing Systems (NeurIPS) in Vancouver, BC.

Most recent results from this project have now been submitted as a conference paper, and the project team is already planning the next phase which will expand the use of developed methods and systems to other marine species.

A sample AZFP echogram showing regions of interest and classification results based on Machine Learning.
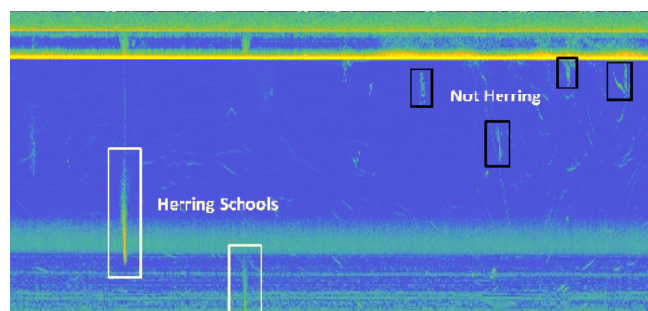
Airborne Hyperspectral Survey and Mineral Mapping in South Greenland

ASL Environmental Sciences, following a tender process, has entered into a contract with the Ministry of Mineral Resources, Government of Greenland. Under this contract, ASL will process and analyze a large amount of airborne hyperspectral data in order to produce mineral maps for the Gardar Province in south Greenland.

◀ View of the town of Narsaq from aircraft collecting hyperspectral data in South Greenland (Credit: Ministry of Mineral Resources).

Hyperspectral remote sensing (also referred to as imaging spectroscopy) provides image data recorded in a large number of wavelengths, many outside of the human visual range. The image data can be used in the same fashion as a laboratory spectrometer, to detect and quantitatively map spectral features specific to many minerals. By comparing on-ground hyperspectral measurements with the airborne measurements, it is possible to find areas where a given mineral has not been previously registered.

The Gardar Province comprises a suite of Proterozoic alkaline igneous rocks associated with continental rifting in South Greenland. In this area there are great opportunities to make new discoveries of a variety of mineral resources, including rare earth elements. Part of the province includes the Ilimaussaq Intrusion, which contains rare earths and where Greenland Minerals Ltd and Tanbreez Ltd have exploration permits. The region also includes many other areas that have been underexplored and have significant mineral potential.

The hyperspectral study and mineral mapping of the Gardar Province is a collaboration between the U.S. Department of State and the Greenland Ministry of Mineral Resources. The first phase of the project consisted of collecting airborne and land-based data. Field operations were conducted from late July to early August 2019 by project partners including the Greenland Ministry of Mineral Resources, the U.S. Department of State, the U.S. Naval Research Laboratory, the U.S. Geological Survey, and Asiaq - Greenland Survey. The next phase of the project will include processing and analysis of the hyperspectral data. ASL's team of researchers, analysts and geologists will generate a range of information products and maps in collaboration with the Greenland Ministry of Mineral Resources. This data will be made available publicly and free of charge by the end of 2020. This will provide the industry with new, high-quality data and improve the ability to promote foreign investment and local employment. Foreign investment in the mineral resources sector is one of the Government of Greenland's main goals in order to diversify the Greenlandic economy.

The ASL remote sensing group (formerly G.A. Borstad Associates) has more than 40 years of experience in hyperspectral data collection as well as processing and analysis of both airborne and space-based data. The data can, for example, be used for monitoring the aquatic and terrestrial environment, mapping minerals and other research.

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GOVERNMENT OF GREENLAND

SeaCycler Interactive Deep Ocean Observatory Adds ASL's Acoustic Zooplankton Fish Profiler to Payload

The SeaCycler is a long-term interactive deep ocean observatory that is equipped with a large payload of oceanographic instruments. It was a key part of the VITALS project that was examining atmospheric gas exchange and deep convection in the Labrador Sea (Atamanchuk et al., 2020). This system was originally developed in collaboration between Bedford Institute of Oceanography, Canada (George Fowler) and Scripps Institution of Oceanography, USA (Uwe Send) but has expanded internationally with partnerships that include Helmholtz Centre for Ocean Research Kiel (Germany) and most recently, Dalhousie University's CERC.OCEAN group led by Prof. Doug Wallace. In collaboration with Dr. Dariia Atamanchuk of the University of Dalhousie and Dr. Maxime Geoffroy of the Fisheries and Marine Institute of Memorial University of Newfoundland, an ASL Environmental Sciences' Acoustic Zooplankton Fish Profiler (AZFP) (multi-frequency 38/70/125/200 kHz) has been added to the instrument payload to continuously record acoustic backscatter in the water column.

The SeaCycler has a large array of instruments including those that measure dissolved gases, nutrients, currents and biooptical properties of seawater. Many of the instruments are mounted to the sensor float which can be raised or lowered through the water column to either profile or sample at discrete depths. The mechanism float is comprised of an energy-conserving winch that controls the movement of the sensor float through 150 m of the upper ocean. As the sensor float moves towards the surface, the communication float surfaces and allows for two-way satellite communications between the instruments and the shore station. The AZFP has been mounted to the mechanism float with two of its four transducers pointing up to detect bubbles, fish and zooplankton and two transducers pointing down to detect fish and zooplankton.

Sea trails are being conducted in preparation for a long-term deployment of the SeaCycler in the Labrador Sea planned for September of this year.
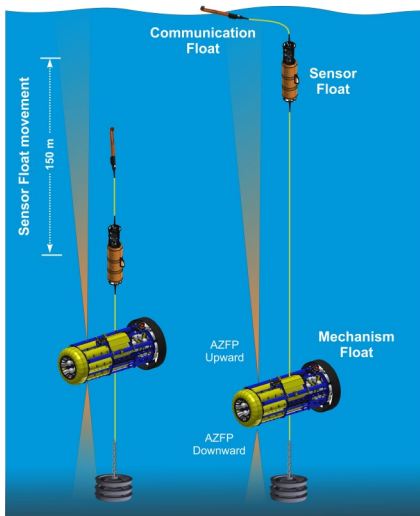
Sea Cycler schematic.

Photo of the mechanism float underwater winch assembly showing the white cylindrical pressure case of the ASL's AZFP. Inset shows Dr. Atamanchuk (second from right) with the SeaCycler team (left to right): Greg Siddall, Aaron McNeill, Mike Vining, Piotr Kawalec (Photo credit: Dalhousie University).

ASL Environmental Sciences, Part of the Marine Arctic Ecosystem Study (MARES) Wins 2019 Excellence in Partnering Award

ASL was part of a team of organizations called the Marine Arctic Ecosystem Study (MARES) that won the 2019 US National Oceanographic Partnership Program (NOPP) Excellence in Partnering Award. The award was presented at the 2020 Ocean Sciences Meeting in San Diego, California on February 20, 2020.

The Excellence in Partnering Award is presented annually to a NOPP project that demonstrates strong partnerships with objectives to advance our understanding of the ocean sciences. The MARES project integrates several organizations that include academic, private, tribal and state government with a focus on understanding the dynamics of the Arctic marine ecosystem in the eastern Beaufort Sea. This coordination of effort produced new insights from a broad range of sensors yielding a more complete understanding of the structure and function of this remote marine ecosystem.

MARES was initiated by senior scientist Dr. Guillermo Auad of the Bureau of Ocean Energy Management (BOEM). It was led by Dr. Francis Wiese of Stantec Consulting Services.

ASL's role in this collaboration was to provide a lead role in the physical oceanographic data collection, along with the Woods Hole Oceanographic Institution. ASL provided most of the instruments for four highly instrumented moorings, including ADCP and ice profiling sonars (IPS) which were operated over two full years from September 2016 to October 2018. ASL was also instrumental in the collaboration with the Department of Fisheries and Oceans (DFO) to provide ship time on the CCGS Sir Wilfrid Laurier in support of the mooring operations.

NOPP Excellence in Partnering Award presented to members of the MARES team.
(L-R) Jan Buermans (ASL), Matthew Asplin (ASL), David Fissel (ASL), Jeff Green (Stantec), Francis Wiese (Stantec), Ruth Perry (Shell), Guillermo Auad (BOEM), Diane Ingraham (Stantec), Rachel McMahon (Old Dominion University), Pamela Neubert (AECOM), Rowenna Gryba (Stantec), Andrew VonDuyke (North Slope Borough), Donglai Gong (Virginia Institute of Marine Science), Natalie Monacci (University of Alaska Fairbanks)

Update on Laura Hobbs and Roland Proud, AZFP Recovery
# Lake Victoria, East Africa

In 2019, Dr. Laura Hobbs (University of Strathclyde and Scottish Association for Marine Science) and Dr. Roland Proud (University of St. Andrews) won the ASL Environmental Sciences annual early career competition to have use of, free of charge, an Acoustic Zooplankton Fish Profiler (AZFP) to study fisheries ecology in Lake Victoria (East Africa). Following their proposal, the instrument was deployed in the deepest part of the lake (c. 70 m of water depth) on the 30th November 2019.

Dr. Proud and Prof. Andrew Brierley (University of St. Andrews) returned to Uganda in February 2020 to recover the AZFP. As part of the instrument recovery trip, Dr. Proud and Prof. Brierley ran an acoustics course with 20 fisheries scientists from the Lake Victoria Fisheries Organisation (LVFO, Uganda), Tanzania Fisheries Research Institute (TaFIRI, Tanzania), Kenya Marine and Fisheries Research Institute (KMFRI, Kenya), and the National Fisheries Resources Research Institute (NaFiRRI, Uganda). During the course, participants learned how to process AZFP data, converting raw files in to echograms (echo energy plotted by depth and along-track distance/time) using Python and Echoview. Preliminary analysis of the data revealed patterns in the vertical movement of organisms in the water-column and the complex interplay of predator-prey interactions during daily and seasonal cycles (see figure for example echogram).

Back in the UK, Dr. Proud and Dr. Hobbs are working on the data to answer key ecological questions linked to the Lake Victoria fishery, which supports more than 35 million people in East African Communities. They hope that this work will lead to future deployments in the lake and further collaboration with local scientists. Deployment of the AZFP was also supported financially by the University of Strathclyde, the University of St. Andrews, and through funds obtained from the Scottish Funding Council Global Challenge Research Fund.

AZFP mooring recovery: Collins Ongore (white cap), fisheries scientist at KMFRI and PhD student at the University of St. Andrews, ferrying the AZFP back to the RV *Ibis* with help from crew members.
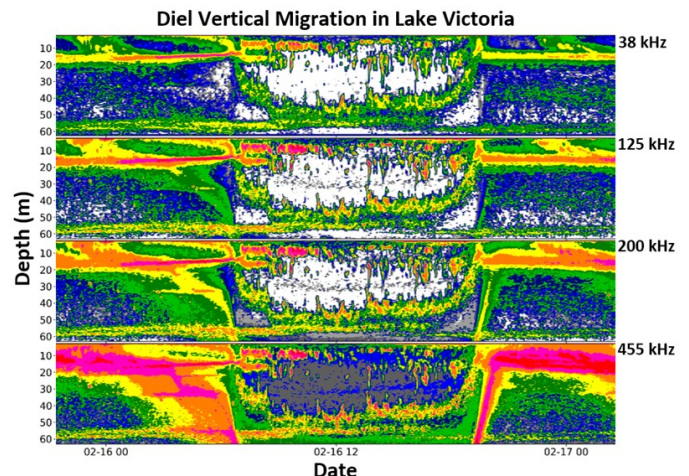
Four stacked echograms (38 kHz, 125 kHz, 200 kHz and 455 kHz) showing diel vertical migration in Lake Victoria. Data collected during February 2020. Date format (month-day time).

ASL Opportunity

Masters Student Position: Fishery Acoustics Specialist

Memorial University of St. John's Newfoundland, in collaboration with ASL Environmental Sciences, has an opening for a graduate level student interested in the biological, oceanographic or acoustics disciplines. This position will focus on the development of software models to predict sonar system performance and to explore new processing techniques. In addition to the modeling of sonar performance and processing techniques, this position will also have a field work component. ASL Environmental Sciences, based in Victoria, British Columbia, has more than 40 years of experience in acoustics, oceanography, ice research, remote sensing and operational services. We provide scientific consulting and instruments to Canadian and international clients from industry, government and academic sectors.

For a list of responsibilities and qualifications for this position, please see our careers page (https://aslenv.com/careers.html) or click here for posting. This graduate position is fully funded.

# ASL Wins Three-year Standing Offer to Provide DeepWater Buoyancy Floatation for DFO 's West Coast Deployments

ASL is pleased to announce that it has won a three-year standing offer with the Department of Fisheries and Oceans Canada (DFO) to supply DeepWater Buoyancy floatation for DFO's West Coast deployments. ASL has a large selection of syntactic foam floatation suitable for deep water deployments and is the British Columbia, Alaska and Alberta product representative for DeepWater Buoyancy.

For more information on syntactic foam products or this standing offer, please contact James Bartlett (Oceanographic Services Scientist/Technical Sales)jbartlett@aslenv.com +1 250 656-0177 ext 153.

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Interesting Times

As a company, we are complying with the latest advice from our authorities in an effort to flatten the curve. Our staff is fully equipped to function as close to "normal" from our homes, utilizing remote desktop utilities, webcams and e-mail to continue to work with our valued customers. A core group continues to work on-site, while respecting physical distancing and other guidelines. This group is maintaining key operations such as facility management, manufacturing and equipment leasing. We encourage our customers to reach out and discuss any questions or requirements they may have.
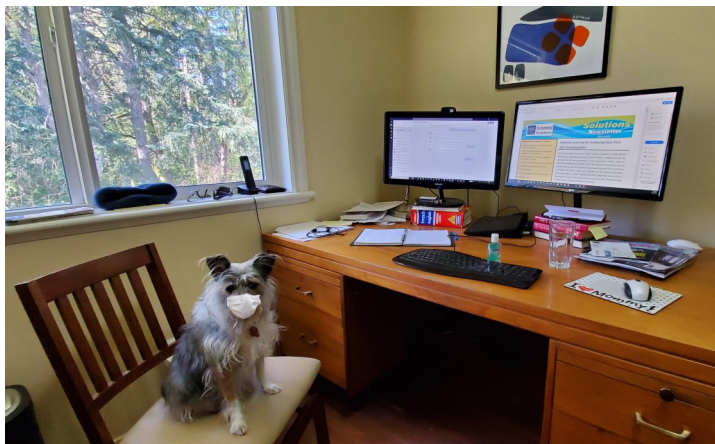
From our company to you, we hope that you stay safe and healthy. We look forward to working with you on your next project.

☀ Coming Soon. ASL to Announce Early Career Scientist Contest to Win the Use of an Autonomous Scientific Echo Sounder for Three-Months

Stay tuned. ASL will soon be announcing its 5th annual AZFP award contest. The goal of this open proposal program is to support the oceanographic research community by lending, free of charge, a battery-powered AZFP (either 125/200/455/769 kHz or 38/125/200/455 kHz configuration), plus mooring cage and battery for a three-month maximum deployment period along with the support from ASL's team of experts. This instrument loan program is open to early-career scientists and engineers, graduate students, post-doctoral fellows and others involved in oceanographic or freshwater work.

Over the years, early career scientists have been awarded the use of a multifrequency AZFP. These instruments have been put to good use as can be seen by the annual press releases below.

https://aslenv.com/assets/files/ASL-Press-release-AZFP-Award-winner-2019.pdf

https://aslenv.com/assets/files/ASL-Press-release-AZFP-Award-winner-2018.pdf

https://aslenv.com/assets/files/ASL-Press-Release-AZFP-Award-winner-July-2017.pdf

https://aslenv.com/assets/files/ASL-AZFP-Award-WinnerPressRelease_April_2016.pdf