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Marine Bioacoustics Workshop, Friday harbour Laboratories, WA.

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In August 2013, I completed a four week workshop in Marine Bioacoustics at Friday Harbor Laboratories (part of the University of Washington).

I am a PhD student based at the Scottish Association for Marine Science (University of the Highlands and Islands), working for the CircA project – "Circadian rhythms of Arctic zooplankton from polar twilight to polar night – patterns, processes, and ecosystem implications ". This project, based mostly in Norway, looks at the causes for Diel Vertical Migration in the Arctic, particularly during the Polar Night during which the day/night pattern does not exist. My part of the project is to study the pan-Arctic patterns, specifically looking at similarities in areas that demonstrate the existence of DVM.

The archive of data that I use is a combination of acoustical data and supporting environmental data such as temperature, salinity, fluorescence and ice cover. Most of the long term recordings of acoustical data come from Acoustic Doppler Current Profilers (ADCP's). Traditionally used to measure currents, the data from these can be analysed in such a way that information regarding sound scattering layers and even the velocities of migrating zooplankton can be found. As part of a previous project, we have an archive of data spreading across the entire Arctic for many years. A benefit of long term moorings is that we can have cross-seasonal data in remote locations, demonstrating how the behaviour of zooplankton changes from the 24 hour daylight in the summer, to traditional day/night light patterns, to the 24 hour darkness of the Polar Night. I also have use of a newer instrument which offers mutlifrequency echosounding, allowing for the interpretation of size classes of migrating zooplankton.

The workshop at FHL covered active acoustics (as in ADCP's, the instrument creates a sound wave which is then reflected off particles (in this case zooplankton) and the returning wave is recorded, providing information regarding the target that was hit) for the first three weeks, and passive acoustics (using hydrophone arrays to record sounds created by marine organisms, such as cetaceans) for the final week. The workshop was split into four key sections: i) the principles of active acoustics, ii) the applications of active acoustics and the use of scattering models and ground truthing, iii) using acoustic tags to track shrimp and fish populations, and iv) designing hydrophone arras to identify and locate cetacean populations.

Summaries of the content of each section are listed below:

<u>The Principles of active acoustics.</u>

- Mathematical introduction to bioacoustics
- Outlines of the theory of transducers/signal creation/output/reflection/receiving/processing
- Scattering and reflection.
- We used a Matlab programme called Digitizer for finding average lengths and widths of individuals. These can be used to create a "predicted backscatter" from net samples, and then

used to look at the predicted vs observed levels of backscatter, suggesting whether the nets samples are collecting everything that is really in the water column.
- The effects of seasonal currents on distribution patterns.

The applications of active acoustics and the use of scattering models and ground truthing.

- Multi frequency methods, and inferring size of target from acoustics.
- Selection of scattering models, and how to select the right basic shape for a complex individual
- The changes in individuals during the year (i.e. fat reserves in winter) can alter their scattering properties
- The use of MOCNESS nets (Multiple Opening Closing Nets and Environmental Sampling Systems).
- Using the Echoview programme to interpret and represent acoustical data

Using acoustic tags to rack shrimp and fish populations

- Using one frequency (307 kHz) at varying time intervals to create a series of tags that can be used simultaneously
- Setting up arrays of hydrophones to record the tags in 3D motion
- Useful in situations such as dam creation, to look at whether fish channels are successful
- Advanced tags also use enzyme activated ping changes to show when an individual has been eaten – can then be used to track a predator

Designing hydrophone arras to identify and locate cetacean populations

- Recognising different behavioural types of acoustical noise – the difference between echolocation clicks and longer calls
- Using >1 hydrophone in an array design to allow for triangulation of individuals using Time Of Arrival Difference (TOAD)
- The acoustical behaviour of local Orca populations

The workshop was taught by leading academics from the Universities of Washington and Cornell, as well as Woods Hole Oceanographic Institute.

In addition to the academic lecturing, we also conducted a day of calibration on board RV Centennial. Using calibration balls rigged under the ship, we were able to calibrate the ship mounted echosounders. We also had a full research day, taking acoustical and net samples in the Saanich Inlet area. This data was processed during the workshop, so that we were working with our own, real data.