Description of the PhD project - Mobile acoustic observation methodologies for cabled ocean observatory transects

Christian Michelsen Research AS (CMR) is a renowned Norwegian science and technology research group with main office in Bergen, Norway. CMR has a long history in the area of marine and arctic observations and works closely with industry, universities and other research organizations in Norway and internationally.

The University of Bergen (UiB) is an internationally recognized research university with more than 14,000 students and close to 3,500 employees, at six faculties. The university is located in the heart of Bergen. Our main contribution to society is excellent basic research and education across a wide range of disciplines.

With a staff of almost 750, the Institute of Marine Research is Norway’s largest centre of marine science. Our main task is to provide advice to Norwegian authorities on aquaculture and the ecosystems of the Barents Sea, the Norwegian Sea, the North Sea, and the Norwegian coastal zone. For this reason, about fifty percent of our activities are financed by the Ministry of Trade, Industry and Fisheries.

At Christian Michelsen Research AS (CMR) (http://www.cmr.no) a 4-year position as research fellow (PhD position) is available within the field of acoustics, entitled “Mobile acoustic observation methodologies for cabled ocean observatory transects”. The position is financed by the Research Council of Norway (NFR), and shall lead to a PhD degree in physics at the University of Bergen.

The PhD work will be carried out in close collaboration between CMR (Science & Technology), the Institute of Marine Research (IMR) (the Marine Ecosystem Research group) and the University of Bergen (the Acoustics Group at UiB’s Dept. of Physics and Technology). PhD supervision is made through a supervision team with members from the three collaboration partners, and with UiB as responsible for the main supervision.

Background. The Lofoten-Vesterålen cabled ocean observatory (LoVe) was established in 2013 by Statoil and IMR. A first observation node was launched, and plans for expansion with sensor platforms along a transect line over the continental shelf, from the coast to deep water (2000 m), was developed. In 2015 the expansion of LoVe was funded by the Research Council of Norway through the National Financing Initiative for Research Infrastructure, based on multi-institutional effort. Partners in the infrastructure project include IMR, University of Bergen (UiB), University of Tromsø, Jacobs University Bremen, Forsvarets forskningsinstitutt (FFI), Christian Michelsen Research (CMR), Uni Research, Statoil, GCE Subsea, and Norges fiskarlag.

The extension includes four additional stationary cabled nodes and two “autonomous” nodes, and new nodes are expected to become operational late 2017. Each seafloor-mounted node contains multiple sensors, where e.g. upward-looking echosounders map details about the biomass distribution in the water column around the node, and acoustic Doppler current profiles (ADCP) detail the ocean current profiles in this water column. Ocean current measurements and echosounder observations, together with images of the seafloor ecosystem, are sent by cable from the platform to the onshore station, and are available in real-time on the internet (http://love.statoil.com/).

The scientific idea of LoVe is to establish real-time monitoring that produces four-dimensional properties of observations along the observatory transect (depth • distance from coast • time • flux of observed quantities). The project aims to be an operational framework which in turn will facilitate continuous monitoring of water and biomass flux along the coast by the Norwegian costal and Atlantic currents, thus connecting processes at the coast with those taking place in northern oceans. This will be an important input to substantiate the LoVe slogan “Gateway to the High North”.

Such a perspective requires observations also in-between the stationary cable nodes, and a spatial interpolation model that utilizes all available observations to give the best possible information at the transect along the cable.

PhD work. The objective of the PhD work is to establish a scientific basis for autonomous acoustic observation methodologies onboard mobile autonomous surface vehicles, to enable real-time quality information for inter-node interpolation in a cabled ocean observatory transect. Such observations will
be tested and used at and in-between stationary cable nodes, with emphasis on biomass and ocean current observations.

The PhD work will involve

- Development of autonomous near real-time processing and reporting methodologies of acoustic data onboard mobile autonomous surface vehicles (ASV),
- Implementation and use of such autonomous observation systems onboard a mobile ASV [such as Sailbuoy (Offshore Sensing AS, CMR) and Kayak (IMR)], supplemented by data collected by traditional vessels, e.g. surveying and fisheries vessels, and the cabled ocean observatory nodes,
- Development of spatial interpolation and short-term prediction models for observed data,
- Establishing of a testing and validation framework for the observations and the interpolation models.

This will be achieved through four main steps:

- **Data acquisition.** A state-of-the-art scientific echosounder and an acoustic Doppler current profiler is planned to be installed onboard an ASV, to be used in field surveying at predefined transects. The ASV will navigate along the LoVe transect (or at given distances from it) and collect data continuously (echosounder backscattering, ocean current profiles, temperature, salinity). Additional data will be available from traditional vessels (e.g. fisheries and surveying vessels), and the stationary nodes of the cabled observatory.
- **Onboard processing methods.** The acoustic instruments collect huge amounts of data that cannot be transmitted in real-time. Onboard autonomous processing techniques are to be developed that minimize the information into some key data (such as e.g. the volume backscattering coefficient, $s_v$), for near real-time transmission to the onshore base. Onboard processing methods are to build on and be coherent with state-of-the-art processing methods used in the fisheries industry, such as the Simrad EK80 broadband technology.
- **Inter-node transect interpolation.** Based on data collected from the mobile vessels and stationary nodes of the cabled ocean observatory, spatial inter-node interpolation and short-term prediction models are to be developed and used for improvement and update of the cable transect.
- **Testing and validation.** Observed ASV data may be compared with and tested versus the stationary node observations, and possible additional surface vessel observations. Challenges related to partly incommensurable observation methods (e.g., aspect and frequency dependent backscattering) are to be addressed.

Through the PhD work the candidate will obtain core competence within very dynamic and rapidly developing research fields in ultrasonic instrumentation and ocean technology, of significant economic and industrial importance for Norway and the international community.

The scope of the project is extensive and will be focused at the start of the project, e.g. based on the background of the successful candidate.

**PhD supervision**

The PhD candidate will be supervised by a committee with members from the three research groups involved. PhD supervision will include regular meetings

**Committee:**

Professor Per Lunde, Department of Physics and Technology, acoustics research group (and a 20 % secondary position as scientific advisor at Christian Michelsen Research AS (CMR)). Supervisor.

Senior Scientist Geir Pedersen, Christian Michelsen Research AS. Member of the supervising committee.

Senior Scientist Olav Rune Godø, Institute of Marine Research. Member of the supervising committee.