Title of Project: Ecology of an important coral predator: eDNA as a novel tool to investigate different life-history stages of Crown of Thorns Seastars *(Acanthaster cf. solaris)*

Names of supervisors:

Name	Affiliation (AIMS or JCU)
Sven Uthicke	AIMS
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Brief description of the project

Crown of Thorns Seastars (CoTS) are important coral predators. On the Great Barrier Reef, CoTS outbreaks may have been responsible for over 40% of the recent coral cover decline. The reasons for these outbreaks are still under debate, possible explanations range from bottom-up ('nutrient limitation hypothesis') to top-down hypothesis ('predator removal hypothesis'). At least to some degree, the confusion about the causes is due to a lack of knowledge on the ecology of CoTS, especially of early life history stages: Planktonic larval stages are hard to distinguish from other echinoderm species and post settlement juveniles are cryptic. Our team has recently developed molecular probes which allow detection and quantification of larval stages, and potentially also juveniles. These 'eDNA' tools open new alleys to investigate the ecology of larvae and juveniles of CoTS, such as temporal and (large and fine scale) spatial distribution.

This project falls within the Research Goals of the 'Tropical marine water quality and impacts' with the objective (1.3) to 'Develop strategic research and effective solutions for the management and control of Crown of Thorns Starfish'. It is also relevant to more projects at AIMS mainly the 'Technology development to support studies of environmental levers for COTS, and Implementation of the crown of thorns research strategy: regional strategies'.

The project is well housed in a research program on Crown of thorns sea star outbreaks at AIMS. Over the last years we had several internal and external (NESP, Australian Museum, GBRMPA) research projects to develop eDNA techniques to detect CoTS. A method to quantify larvae from the plankton has now been finalised and published. Current projects (NESP2, 3) use similar techniques to develop genetic methods to identify the presence of post-settlement CoTS based on 'free' DNA in the water, or identify predators on CoTS by faeces analysis.

Thus, this project is well placed in ongoing AIMS projects and can contribute to further applying genetic markers to resolve ecologic questions concerning detection of outbreaks and understanding causes causing outbreaks

We have an ongoing collaboration on CoTS issues with Morgan Pratchett. There is a collaboration through CoTS NESP projects, and currently one of MP's technicians is analysing settlement traps with genetic methods at AIMS PC2 lab. SU has co-edited a special issue of 'Diversity' with MP early this year.

This project would suit someone who: is highly motivated with both genetic laboratory and ecological skills who is interested in using these tools along with the development of further methods to shed more light on the ecology of CoTS and contribute to new management solutions.

Key words: reef-degradation, crown-of thorns-seastar, molecular tools, eDNA, echinoderms

Title of Project: Machine learning approach to restoration, prediction and quality control of oceanographic data from IMOS Moorings

Names of supervisors:

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Brief description of the project

Reliable data on the state of the ocean and coastal areas are in growing demand. For the past 10 years, the Australian National Mooring Network, as part of the Integrated Marine Observing System (IMOS) has measured physical and biological parameters at over 50 sites in Australian coastal waters.

The resulting data collection consists of a huge amount of time series information across many variables. Processing these data sets currently requires a significant amount of human-in-the-loop overheads for quality control and data processing. Furthermore, on occasion field instrumentation will fail due to the adverse ambient conditions and/or faulty manufacturing. The presence of gaps in data records may render the period of observation unsuitable for many practical purposes e.g. where a continuous record is required for numerical model validation or calibration.

It has been demonstrated in a range of recent studies that meshless data–based methods of time series interpolation and expansion, which include stochastic models as well as artificial intelligence approaches such as genetic algorithms, fuzzy logics, artificial neural networks (ANNs) [2-4], may be beneficially used to estimate met-ocean parameters. Other recent studies have demonstrated that a Bayesian network can be trained to conduct quality control of real time measurements from IMOS oceanographic sensors [5].

This project provides a candidate the opportunity to investigate a machine learning approach to increasing the value of oceanographic data. The full collection of IMOS Moorings data will be available for use in developing and training algorithms. Much of this data has already been flagged by heuristic quality control routines, and manually annotated by domain experts.

This PhD project will contribute to the following tasks:

- Investigate a machine learning approach to automate the quality control process of oceanographic data by flagging anomalies and outliers
- Develop an approach and implement an artificial intelligence technique to the task of data gap interpolation;
- Develop a forecasting methodology for extrapolating data on different timescales.
- Analyse and understand the relationships between different oceanographic, water quality and ecosystem parameters in the tropics

[1] http://imos.org.au/nationalmooringnetwork.html
[2] Makarynskyy, O., Makarynska, D., Kuhn, M., Featherstone, W. E., 2005. Using artificial neural networks to estimate sea level in continental and island coastal environments. Hydrodynamics IV: Theory and Applications, L.Cheng and K.Yeow (eds.), Taylor & Francis Group, London, 451-457.
[3] Makarynskyy, O., Makarynska, D., Rusu, E., Gavrilov, A., 2005. Filling gaps in wave records with artificial neural networks. Maritime Transportation and Exploitation of Ocean and Coastal Resources, C.Guedes Soares, Y.Garbatov and N.Fonseca (eds.), Taylor & Francis Group, London, 1085-1091.
[4] Makarynskyy, O., 2005. Artificial neural networks for wave tracking, retrieval and prediction, Pacific Oceanography, 3 (1), 21-30.
[5] Smith, D.; Timms, G.; De Souza, P.; D'Este, C. A Bayesian Framework for the Automated Online Assessment of Sensor Data Quality. *Sensors* **2012**, *12*, 9476-9501.

This project would suit someone who: possess and be willing to further develop high-level quantitative analysis and machine learning techniques to progress this project. The PhD project proposal will be developed around analysis of IMOS oceanographic and water quality parameters. The candidate is expected to possess and be willing to further develop high-level quantitative analysis and machine learning techniques to progress this project. Demonstrated strong skills in programming and data science will be required. The candidate should have an interest in understanding and working with large collections of oceanographic data. Some previous exposure to oceanography would be highly regarded.

Key words: Machine Learning, artificial neural networks, automated quality control, algorithm development, IMOS data, artificial intelligence, statistics, interpolation, prediction