

Offer for a 6-week Summer Project/Internship Student Placement at Edinburgh Napier University

- **Title of project:** Production of final version smartphone application and data queries for citizen science research in Brazil to improve mangrove crab fisheries management

- **Brief background to the project, aims and objectives:**

The proposed summer placement, with its own specified aim/objectives (see below), is linked to a larger programme of research, the REMAR network project, led by Dr Karen Diele, School of Applied Sciences at Edinburgh Napier University (ENU) and Dr Anders Schmidt (University of Southern Bahia, Brazil). REMAR focusses on the biology and fisheries management of the mangrove crab *Ucides cordatus*. The species plays important cultural, ecological and socioeconomic roles in Brazil¹⁻⁴, providing the livelihood for ten-thousands of (marginalized) fishers⁵. Since the slow-growing crabs are vulnerable to overfishing^{6,7}, the Brazilian government has implemented a suite of fishing rules⁸. During the last decades however, regulatory agencies have increasingly lost credibility due to a mismatch between precautionary temporal capture bans and the crabs' mass mating events. This led to conflicts and law in compliance⁹. REMAR, with its nine Brazilian partner institutions, aims to develop a Brazil-wide applicable tool to allow optimizing the placement of these capture bans. Specifically, REMAR is testing the hypothesis that the occurrence of the mass mating is linked with geophysical cycles and therefore is predictable in time, over large spatial scales and in different environmental contexts. Diele and Schmidt observed such linkage in one *Ucides* population in north-eastern Brazil and identified what they named the *Syzygy Tide Inequality Cycle* (STIC) as the driver of the temporal pattern of the mass mating⁹. STIC is a superposition of the synodic neap-spring cycle with the anomalistic cycle. The latter describes the differing distances of the moon relative to earth while it moves along its elliptical orbit, with apogee being the furthest and perigee being the nearest point to earth. Mass mating occurs when either full or new moon coincide with perigee, probably due to the then highest tidal amplitudes (to facilitate estuarine larval export and thereby increase larval survival¹⁰). Since tides are an important factor for the reproductive success of *U. cordatus*^{9,10}, REMAR was designed to scale-up and generate long-term field-data from nine macro-, meso- and microtidal sites, with a distance of > 4000km between the most northern- and southernmost ones. Supplementary information from other coastal locations in Brazil is desirable to further test above hypothesis and allow the development of a new tool to robustly predict the occurrence of mass mating of *U. cordatus* across entire Brazil, and therewith to optimize fisheries management and improve the fishers incomes.

For additional data collection beyond the nine REMAR study sites, support through citizen-science is needed. In 2016, with Emma Hart and colleagues/students from the School of Computing at Napier, we began to develop the smartphone application REMAR_CIDADÃO (REMAR_CITIZEN). The alpha-version is currently being tested by a group of fishers/managers in Brazil. The data are sent to a server located at Napier.

The overall aim of the anticipated activity under the offered student placement over the summer 2017 is to produce a finalized REMAR_CIDADÃO app and customized server interface, ready-to-use by a wide range of stakeholders in Brazil and Scotland (implementation/distribution of the app planned for November 2017).

The objectives of the student placement are to:

- download and analyse data on the REMAR server received from end-users testing the alpha-version app in spring 2017
- identify any problems the test persons have encountered while using the alpha-version; trouble-shooting (i.e. re-programming)
- programme customized automatic queries to facilitate data retrieval and transmission to end user (i.e. researchers Diele & Schmidt)
- “brush app” the design of the app by adding an attractive first and last “page”

▪ **Description of project methods, skills required/training:**

The project is a great opportunity to work within an interdisciplinary team of biologists and computing scientists in a context with real-world implications. The computing student will gain insights how computing can support applied fisheries sciences and to understand methodologies associated with data-collection and processing in large projects.

Methods

Liaise with Diele and Hart to

- understand the needs of app users in Brazil and to discuss possible methods to optimize the app
- update app to reflect user requirements
- develop data-query and analysis system to enable researchers to identify trends/features in data
- develop graphical presentation methods to display analysed data and enable users to interact with data

Skills needed (and further training in):

- User design skills
- App development skills (Android)
- Basic understanding of data-analysis/statistics and graphical libraries for displaying data

Further important:

- Good team worker and open-minded for interdisciplinary work
- Ability to communicate well with potential end users
- Patience and thriving to perfection

▪ **Expected outputs**

- Final version of the smartphone app REMAR_CITIZEN, easy-to-use and ready for nation-wide distribution/ implementation in Brazil from November 2017 onwards
- Customized automatic queries/data output from REMAR data-storage server at Edinburgh Napier University, to be used in research conducted by Karen Diele and Brazilian partners
- Graphical interface providing visualisation of data/ability for researchers to interact with data

▪ **Brief description of importance of project to MASTS, the Fisheries Science Forum, and wider impacts**

- The aims of the internship and the underlying larger research programme are closely in line and thus benefitting the Fisheries Science Forum and MASTS , i.e. to provide research and advice relevant to sustainable fisheries management
- MASTS and the Forum would benefit from further internationalisation by supporting a relevant bilateral project with Brazil
- Increased visibility through an app which (hopefully) will be used by many in Brazil

- In addition to an expected societal impact regarding fisheries management in Brazil, the placement would support the attempt of developing a REF impact statement of a MASTS member

Relevant references

1 - Diele, K., Araújo, A.R., Glaser, M., Salzmann, U. (2010) Fishery of the mangrove crab *Ucides cordatus* in N-Brazil: First steps to successful co-management. In: Mangrove Dynamics and Management in North Brazil (U. Saint-Paul & H. Schneider, Eds.). *Ecological Studies*, Springer, Berlin-Heidelberg Vol. 211: 287-297. **2 - Nordhaus, I., Wolff, M., Diele, K. (2006)** Litter processing and population food intake of the mangrove crab *Ucides cordatus* in a high intertidal forest in northern Brazil. *Estuarine, Coastal and Shelf Science* 67: 239-250. **3 - Puelmanns, N., Diele, K., Mehlig, U., Nordhaus, I. (2014)** Burrows of the semi-terrestrial crab *Ucides cordatus* enhance CO₂ release in a North Brazilian mangrove forest. *PlosOne* 9(10): e109532. **4 - Glaser, M., Diele, K. (2004)** Asymmetric outcomes: Assessing the biological economic and social sustainability of a mangrove crab fishery, *Ucides cordatus* (Ocypodidae), in North Brazil. *Ecological Economics* 49(3): 361-373. **5 - Nascimento, D.M., Alves, A.G.C., Alves, R.R.N., Barboza, R.R.D., Schmidt, A.J., Diele, K., Mourao, J.S. (2017)** Commercial relationships between middlemen and harvesters of the mangrove crab *Ucides cordatus* in the Mamanguape River estuary and their socio-ecological implication. *Ecological Economics* 131: 44-51. **6 - Diele, K., Koch, V. (2010)** Growth and mortality of the exploited mangrove crab *Ucides cordatus* (Ucididae). *Journal of Experimental Marine Biology and Ecology* 395: 171-180. **7 - Diele, K., Koch, V., Saint-Paul, U. (2005)** Population structure and catch composition of the exploited mangrove crab *Ucides cordatus* in the Caeté estuary, North Brazil: Indications for overfishing? *Aquatic Living Resources* 18: 169-178. **8 - Nascimento, D.M., Alves, A.G.C., Alves, R.R.N., Barboza, R.R.D., Diele, K., Mourao, J.S. (2016)** An examination of the techniques used to capture mangrove crabs, *Ucides cordatus*, in the Mamanguape River estuary, Northeastern Brazil, with implications for management. *Ocean & Coastal Management* 130:50-57. **9 - Schmidt, A.J., Bemvenuti, C.A., Diele, K., (2012)** Effects of geophysical cycles on the rhythm of mass mate-searching of a harvested mangrove crab. *Animal Behaviour* 84: 333-340. **10 - Diele, K., Simith, D.J.B. (2006)** Salinity tolerance of northern Brazilian mangrove crab larvae, *Ucides cordatus*: Necessity for larval export? *Estuarine, Coastal and Shelf Science* 68: 600-608

Title of project to be based at Victoria Quay, Edinburgh

Scotland's Fish Stocks Compendium: compiling the story of Scotland's key fish stocks into a key policy tool

Brief background to the project

Most fish caught by Scottish fishermen are managed under the Common Fisheries Policy (CFP). An important part of the management process is the use of Total Allowable Catches (TACs) and quota which define the amount of fish that may be caught each year.

TACs and quota are set at annual international negotiations which draw on scientific advice on the current status and size of fish stocks, estimated future stock levels and recommended fishing levels for individual fish stocks that is published each year by the International Council for the Exploration of the Seas (ICES).

Member states are required to fish within sustainable limits. Therefore ICES' stock assessments, both past and present, provide fishery managers in the Scottish Government, other member states and European Commission with the necessary information with which to engage in negotiations about how much fishing should take place and where.

These negotiations are highly technical and fast moving, drawing on current and historic information about the stocks. Scottish Government negotiators therefore need ready access to clear, concise and accurate information about the story of each stock - past, present and future.

Aims/Objectives of the project

This main aim of the project will be to prepare a key policy tool that will become an invaluable resource for the Scottish Government's fisheries teams to draw on in both TAC and quota negotiations and wider BREXIT negotiations going forward. It will enhance and streamline the established links that the Scottish Government's fisheries managers make to the scientific and numerical information that decisions are based on.

The compendium will include vital pieces of information for key Scottish stocks, set out yearly and going back a minimum of 5 years (but further if time permits). Although the exact contents are to be determined (in part through discussion with the successful intern) it is likely to include:

- (1) **numerical information**, to include *inter alia* stock status, TACs, shares (relative stability or Coastal States) and FQA distribution, catch data and uptake, economic values etc.;
- (2) **management information**, to include *inter alia* fishing areas, past/current agreements at an international and EU level, negotiation outcomes (e.g. TAC changes, technical measures, access arrangements), identifying where agreements or TAC setting have departed from the norm, long term management strategies etc..

The project's objectives are:

- *Week 1*: To assist the Scottish Government's International Negotiations team to define the science, numerical information and management data necessary for the project.
- *Week 1-3*: Complete technical research, gathering and collating numerical, scientific and management information for the 19 key stocks of commercial importance to Scotland, going back a minimum of 5 years and further if time permits.

- *Week 3- onwards:* Compile this information clearly and in a way which is appropriate for Scotland's fisheries managers in preparation for annual negotiations.

This project will provide an excellent opportunity to work at the interface of science and policy in a dynamic and complex area. It will provide an understanding of how policy makers use scientific information to establish negotiating positions en route to setting sustainable TACs and quota for Scotland's key commercial stocks. It will produce materials that will be of immediate and direct use in influencing real-world outcomes for Scotland.

Description of project methods to be used, and information about whether the student needs to have any specific skills to be able to complete the project or whether training will be available in specific methods/skills.

Essential skills required are an attention to detail, a concern for accuracy and excellent organisational skills with the ability to prioritise and plan workloads, seeking support when needed.

On the job training will be provided to introduce the policy environment at a Scottish, UK and EU level, in which the work produced during this project will be used. Training will also be provided on Scottish Government systems and information tracking templates to be used during this project.

The project will be based mainly in Scottish Government's Victoria Quay offices in Leith, Edinburgh. However, there are likely to be opportunities to travel to meetings attended by Scottish government officials and the Scottish Fishing industry. Travel and subsistence for attendance at any meeting out with Edinburgh will be covered by Marine Scotland.

Expected outputs from the project

The expected output is to produce a fish stocks compendium that can be used as a key policy tool and working document by Scotland's fisheries managers to help inform decision making and as a quick reference guide during negotiations.

Brief description of importance of project to MASTS, the Fisheries Science Forum, and wider impacts

This project aligns well with MASTS' mission. It will help facilitate the Scottish Government in following some of the principles underpinning our negotiating strategy; to follow best available scientific advice, progressive moves to sustainable fishing levels for all stocks as far as possible, maintaining stocks above safe biological limits and in good reproductive health with provisions for rectifying stock difficulties as they occur; and to protect the socio-economic wellbeing of our industry and the communities that depend on it. This aligns with the aims of both the MASTS Productive Seas Theme and the Fisheries Science Forum.

This project will be able to utilise the 2015 Fisheries Innovation Scotland report '*A review of Scotland's Marine Fisheries Stock Status knowledge gaps, research requirements and stakeholder engagement*' as a resource to help build a picture of the current science in preparation to creating this policy-focussed/oriented resource.

Any relevant references

Scottish Government, Marine Scotland's Sea Fisheries pages:
<http://www.gov.scot/Topics/marine/Sea-Fisheries>

The International Council for the Exploration of the Sea (ICES), Latest Advice:
<http://www.ices.dk/community/advisory-process/Pages/Latest-Advice.aspx>

FIS Report: A review of the status of Scotland's capture fisheries and research and innovation projects highlighting knowledge gaps and data resources :
<http://www.fiscot.org/media/1283/fis001-2.pdf>

Title of project to be based at Aberdeen University: Characterising the spatial structure of North Sea demersal fish communities in relation to discard potential and the Landing Obligation

Brief background on the topic: In 2013 a Landing Obligation for pelagic and demersal fish was introduced to the reformed Common Fisheries Policy. Phased enforcement began with a ban on discarding pelagic fish followed by a demersal ban starting in 2016 (European Commission, 2014; European Commission, 2016). Implementation of the Landing Obligation is easier for pelagic species due to their schooling behaviour which allows for more exclusive selection of the target species. This is not the case for demersal fish. The mixed nature of North Sea demersal fish communities greatly restricts the selectivity of bottom trawling, making implementation of the Landing Obligation difficult. Regulations of fishing, via spatial closures and enhanced selectivity of gear have been trialled, but show inconsistency in reducing discard rates (Graham *et al*, 2007; Catchpole *et al*, 2005).

From an ecological perspective it is well known that species diversity strongly varies with location across a broad range of geographic regions and taxonomic groupings including terrestrial mammals (Simpson, 1964 ; Badgley & Fox, 2000; Williams *et al*, 2002), birds (Lennon *et al*, 2001; Robinson *et al*, 2000), amphibians and reptiles (Kiestler, 1971; Duellman, 1988), marine fish and benthic communities (Callaway *et al*, 2002; Greenstreet & Hall, 1996), and plants (Hernandez-Stefanoni & Ponce-Hernandez, 2006). Local, regional and global diversity patterns have been explored individually as well as their relationship to each other, though spatial relationships appear intrinsically scale-dependent (Ricklefs, 1987; Caley & Schluter, 1997; Lennon *et al*, 2001; Williams *et al*, 2002)

The spatial structure of fish diversity in the North Sea is generally overlooked by management bodies managing fish stocks on a single species approach (Greenstreet & Hall, 1996). A decreasing northwards gradient in diversity of the North Sea fish community, as well as spatial and temporal changes in ground fish community composition, has been identified (Callaway *et al*, 2002; Greenstreet & Hall, 1996). These earlier studies of the North Sea have however, been performed with low spatial resolution with either few sampling locations, or spatially aggregated data (Callaway *et al*, 2002; Greenstreet & Hall, 1996). The implications of spatial structure have not previously been considered through the lens of implementing the Landing Obligation. Improved knowledge of the spatial structure in diversity of the demersal fish could inform our expectations of the likely success of spatial selectivity measures.

Aims: The first aim of this project is to map the spatial structure of community diversity for all North Sea demersal fish. The Landing Obligation applies only to commercial species which are under quota management. Therefore, the second aim is to map the spatial structure of just commercial species that are targeted by the Scottish fishing industry (cod, haddock, saithe, ling, angler, hake, whiting, megrim, lemon sole, plaice, witch, halibut, turbot, dab, and monkfish). These two maps will then be compared to evaluate spatial patterns in discard potential of non-target demersal fish species. In areas of high species diversity trawl selectivity is harder to achieve and therefore there is greater discard potential.

Research questions: Q1) Does species diversity of demersal fish community in the North Sea show spatial structure such that high diversity areas can be distinguished from low diversity areas?; Q2) Does the diversity of commercial species of demersal fish show spatial structure?; and Q3) Does the discard potential of non-target demersal fish species show spatial structure?

Description of Methods: The dataset which will be used for the analysis is derived from the International Bottom Trawl Surveys (IBTS). Surveys began in 1960's and are now conducted twice per year in quarter 1 (January-February) and quarter 3 (July-August). The ICES (International Council for the Exploration of the Sea) stores, standardises and data checks survey information in DATRAS

(https://datras.ices.dk/Data_products/Download/Download_Data_public.aspx). To focus on the region of the North Sea most relevant to the Scottish industry a sub set of species-specific CPUE (catch per unit effort) per length per haul for the North Sea IBTS (NS-IBTS), excluding the Kattegat and Skagerrak and English Channel, will be downloaded. The data set will be filtered so as to exclude size classes that are unavailable to the fishing industry. For initial exploratory analyses the CPUE data will be aggregated for 5 year period (2011-2016) and separated for quarter 1 and quarter 3 surveys. To answer Q1, all demersal species caught will be included, whereas, only a subset of commercial fish species will be taken to answer Q2. Community diversity will be assessed through two indices: species diversity (Shannon-Weiner index, H; used for Q1) and species richness (number of species, used for Q2). These indices will be calculated per haul and then used to create a map showing spatial structure in species diversity across the North Sea. To answer Q3, the two maps will be compared quantitatively by standardising each index and then estimating a sensible ratio, e.g., H/richness, for expressing discard potential. Spatial structuring will be diagnosed using an appropriate statistic for testing the null hypothesis that there is no detectable spatial structure (Moran's I, Mantel test). Temporal variability in these patterns will be considered by using different time windows to aggregate the CPUE data.

The student to be appointed will be enthusiastic about fish and the analysis of large data sets. A background in population ecology is also required. Excel will be used to a limited extent to manipulate the data downloaded from DATRAS. However, the project will allow the student to develop programming skills in R that include data manipulation, estimation of standard ecological indices, mapping and statistical analysis. Training in R will be provided by T. Buch, a MASTS PhD student who is highly experienced with the use of DATRAS. Her PhD focusses on spatio-temporal models of fish abundance and she will be an excellent and helpful resource person to support the student. Statistical support and advice will be available from Dr. Thomas Cornulier, the School's ecological statistician. The supervisor will assist with project management, data interpretation and project write-up.

Expected outcomes: Results will be written up in a format suitable to submission to a fisheries journals.

Importance of the project to MASTS, the Fisheries Science Forum, and wider impacts: This project will increase our fundamental knowledge about where and when biodiversity hotspots occur in the North Sea. Describing the underlying spatial structure of diversity of the North Sea fish community is also relevant towards designing effective strategies to enhance spatial selectivity of fishing. This research is also relevant to ongoing research initiatives in hotspot mapping (Marshall et al. 2017a), the use of real-time area closures (Little et al. 2015) and the ongoing development of highly resolved spatio-temporal models of fish distribution (Marshall et al. 2017b). Linking knowledge of spatial structure to the Landing Obligation will help develop an understanding of both complications to implementation and potential solutions.

References:

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