Abstracts

Brian J. Todd[1], Craig J. Brown[2], Myriam Lacharité[2]

1. Geological Survey of Canada, Dartmouth, Nova Scotia, Canada
2. Nova Scotia Community College, Dartmouth, Nova Scotia, Canada

Table of Contents

Introduction

We welcome you to the sixteenth annual GeoHab Conference, held this year at the Waterfront Campus of the Nova Scotia Community College (NSCC) in Dartmouth, Nova Scotia, Canada. We hope that the climate and culture of Canada's east coast will leave a lasting – and positive – impression with you.

Since its inception in 2001, GeoHab has been a cooperative venture, and the organization of the 2017 Conference exemplifies this spirit. The Nova Scotia Community College has supported the Local Organizing Committee (LOC) from our initial approach more than two years ago. We thank the NSCC Executive for their encouragement and support of the GeoHab Conference, and for providing access to the facilities and cooperation of the talented NSCC staff. The LOC, comprising Beth McCormack, Vicki Gazzola and Myriam Lacharité, along with many other NSCC staff, have toiled for more than a year to ensure the success of the conference. Lindsay Gee (Acoustic Imaging) played a pivotal role in the organization of the technical workshop.

We thank our industry partners for their continued interest in, and financial support of, annual GeoHab conferences around the world. Without this support, GeoHab would not be able to encourage and sponsor students through the Ron McDowell Student Award. We thank Tim Le Bas, Chair of the Student Selection Committee, and his committee members, for their dedication to their task. Student support has always been a mainstay of GeoHab, and in 2017, nine international graduate students will be funded to travel to Nova Scotia to give oral presentations on their research during the conference. The success that past students have enjoyed in their early academic and industry careers in seafloor mapping may be GeoHab's greatest legacy.

The heart of any GeoHab Conference is the oral and poster presentations of exciting new research. We sincerely thank the global cadre of scientists who submitted abstracts this year, with over 100 abstracts received. This rich and diverse material was carefully reviewed by the members of the International Scientific Committee.

Finally, we thank Gary Greene for his practical guidance, financial acumen, and unfailing enthusiasm for the GeoHab organization.

Craig J. Brown, Ph.D.
Research Scientist – Applied Oceans Research
NSCC Applied Research
Nova Scotia Community College
Waterfront Campus
80 Mawiomi Place
Dartmouth, Nova Scotia, Canada B2Y 0A5
Email: Craig.Brown@nscc.ca

Brian J. Todd, Ph.D.
Research Scientist – Marine Environmental Geoscience
Geological Survey of Canada
Natural Resources Canada
Bedford Institute of Oceanography
1 Challenger Drive
Dartmouth, Nova Scotia, Canada B2Y 4A2
Email: Brian.Todd@Canada.ca

NOTE:

The 2017 GeoHab abstracts volume will be published as a Geological Survey of Canada Open File in May 2017, shortly after the conclusion of the conference. The document will be available at www.geoscan.nrcan.gc.ca. Prior to publication, please report any errors or omissions in the abstract volume to Brian Todd at Brian.Todd@Canada.ca.

2017 GeoHab Committee Membership Roster

Local Organizing Committee

- Craig Brown 2017 Co-Chair (Nova Scotia Community College, Canada)
- Brian Todd 2017 Co-Chair (Geological Survey of Canada, Canada)
- Beth McCormack (Nova Scotia Community College, Canada)
- Vicki Gazzola (Nova Scotia Community College, Canada)
- Myriam Lacharité (Nova Scotia Community College, Canada)
- Lindsay Gee (Acoustic Imaging, USA)

International Scientific Committee

- Craig Brown 2017 Co-Chair (Nova Scotia Community College, Canada)
- Brian Todd 2017 Co-Chair (Geological Survey of Canada, Canada)
- Tim Le Bas Past-Chair (National Oceanography Centre, UK)
- Guy Cochrane 2018 Chair (U.S. Geological Survey, USA)
- Gary Greene (Moss Landing Marine Laboratories, USA)
- Daniel Ierodiaconou (Deakin University, Australia)
- Aarno Kotilainen (Geological Survey of Finland, Finland)
- Andrea Fiorentino (Geological Survey of Italy-ISPRA, Italy)
- Margaret Dolan (Geological Survey of Norway, Norway)
- Heather Stewart (British Geological Survey, UK)
- Geoffroy Lamarche (NIWA, New Zealand)
- Kim Picard (GeoScience Australia)

Ron McDowell Student Selection Committee

- Tim Le Bas - Chair (National Oceanography Centre, UK)
- Vaughn Barrie (Geological Survey of Canada, Canada)
- Alex Bastos (Universidade Federal do Espírito Santo, Brazil)
- Guy Cochrane (US Geological Survey, USA)
- Markus Diesing (CEFAS, UK)
- Margaret Dolan (Geological Survey of Norway, Norway)
- Gary Greene (Moss Landing Marine Laboratories, USA)
- Anthony Grehan (National University of Ireland, Ireland)
- Peter Harris (GRID Arendal, Norway)
- David Limpenny (CEFAS, UK)
- Vanessa Lucieer (University of Tasmania, Australia)
- Scott Nichol (Geoscience Australia, Australia)

• Kathleen Robert (National Oceanography Centre, UK)
• Mary Young (Deakin University, Australia)

Table of GeoHab Conferences 2002–2017

Year	Location	Host(s)	Affiliation(s)
2017	Dartmouth, Nova Scotia, Canada	Craig J. Brown Brian J. Todd	Nova Scotia Community College Geological Survey of Canada
2016	Winchester, United Kingdom	Tim Le Bas Markus Diesing Heather Stewart Kerry Howell	National Oceanographic Centre Centre for Environment, Fisheries & Aquaculture Science British Geological Survey University of Plymouth
2015	Salvador, Bahia, Brazil	Alex Bastos Helenice Vital José Maria Landim Dominguez Tereza Araújo	Federal University of Espirito Santo Federal University of Rio Grande do Norte Federal University of Bahia Federal University of Pernambuco
2014	Lorne, Victoria, Australia	Daniel Ierodiaconou Scott Nichol	Deakin University Geoscience Australia
2013	Rome, Italy	Andrea Fiorentino Silvana D'Angelo	Geological Survey of Italy (ISPRA)
2012	Orcas Island, Washington State, USA	H. Gary Greene J. Vaughn Barrie	SeaDoc Society/Tombolo Geological Survey of Canada
2011	Helsinki, Finland	Aarno Kotilainen Anu Kaskela	Geological Survey of Finland (GTK)
2010	Wellington, New Zealand	Geoffroy Lamarche	National Institute of Water and Atmospheric Research (NIWA)
2009	Trondheim, Norway	Terje Thorsnes, Kim Picard, Margaret Dolan Pål Buhl-Mortensen Kari Nygaard Ingrid Bysveen	Geological Survey of Norway (NGU) Institute of Marine Research Institute for Water Research Directorate for Nature Management
2008	Sitka, Alaska, USA	Cleo Brylinski Tory O'Connell, Jennifer Reynolds	Alaska Department of Fish and Game University of Alaska
2007	Nouméa, New Caledonia	Yves Lafoy	Direction de l'industrie, des mines et de l'énergie de Nouvelle-Calédonie
2006	Edinburgh, Scotland	Alan Stevenson Heather Stewart	British Geological Survey
2005	Sidney, British Columbia, Canada	J. Vaughn Barrie Kim Conway	Geological Survey of Canada
2004	Galway, Ireland	Anthony J. Grehan Colin Brown	National University of Ireland, Galway
2003	Hobart, Tasmania	Peter T. Harris Alan Butler	Geoscience Australia CSIRO Marine Laboratories
2002	Moss Landing, California, USA	H. Gary Greene Joe Bizzarro Isabelle Herbert	Moss Landing Marine Laboratories

Table of 2017 GeoHab delegates

* Ron McDowell Student Support Award recipient

Last name	First name(s)	Organization	E-mail
Abdel-Fattah	Sommer	Fisheries and Oceans Canada	sommer.abdel-fattah@dfo-mpo.gc.ca
Albuquerque	Débora	Universidade Federal de Pernambuco	dla.lucatelli@gmail.com
Alevizos	Evangelos	GEOMAR Helmholtz Centre For Ocean Research	ealevizos@geomar.de
Annunziatellis	Aldo	Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA)	aldo.annunziatellis@ isprambiente.it
Araújo	Tereza C.M.	Federal University of Pernambuco, Brazil	terezaraujo.ufpe@gmail.com
Barrell	Jeffrey	Dalhousie University, Canada	jeffbarrell@dal.ca
Beaudoin	Jonathan	QPS	beaudoin@qps.nl
Beazley	Lindsay	Fisheries and Oceans Canada	lindsay.beazley@ dfo-mpo.gc.ca
Blokhina	Kate	Dalhousie University	Kate.Blokhina@Dal.Ca
Borrelli	Mark	Center for Coastal Studies, Provincetown, MA, USA	mark.borrelli@umb.edu
Boswarva*	Karen L.	Scottish Association for Marine Science	karen.boswarva@sams.ac.uk
Bravo	Francisco	Dalhousie University	bravofco@gmail.com
Brisette	Mike	R2 Sonic	Mikeb@r2sonic.com
Broughton	Derek	Sir Alister Hardy Foundation for Ocean Science, UK	derbro@sahfos.ac.uk
Brown	Craig J.	Nova Scotia Community College	craig.brown@nscc.ca
Bruce	Samantha	QPS	bruce@qps.nl
Burchill	Nick	Kongsberg	nick.burchill@km.kongsberg.com
Buscombe	Daniel	Northern Arizona University	daniel.buscombe@nau.edu
Butler	Kevin	ESRI, California	kbutler@esri.com
Carr	Blaine	DASCO	dasco.blaine@gmail.com
Church	Ian	University of New Brunswick	ian.church@unb.ca
Cochrane	Guy R.	US Geological Survey	gcochrane@usgs.gov
Coers	Susanne	University of Bremen	scoers@marum.de
Collier	Ron	SubC	rtc@subcimaging.com
Cruz	Charmaine A.	University of the Philippines	charmaineasiscruz@gmail.com
Davis	Alex C.D.	Oregon State University	davialex@science.oregonstate.edu
Devillers	Rodolphe	Memorial University of Newfoundland	rdeville@mun.ca
Diesing	Markus	Centre for Environment Fisheries and Aquaculture Science, UK	markus.diesing@cefas.co.uk
Dolan	Margaret	Geological Survey of Norway	margaret.dolan@ngu.no
Edinger	Evan	University of Newfoundland	eedinger@mun.ca
Fader	Gordon B.J.	Atlantic Marine Geological Consulting	gordon.fader@ns.sympatico.ca
Fallati*	Luca	University of Milano-Bicocca	l.fallati@campus.unimib.it
Febres Urdaneta	Deborah	QPS Canada	dfebresu@qps.nl
Fiorentino	Dario	Alfred-Wegener-Institut für Polar- und Meeresforschung	dario.fiorentino@awi.de
Foster	Burns	Teledyne CARIS, Inc.	burns.foster@teledyne.com
Freire	Francis	Swedish Geological Survey	francis.freire@sgu.se
Gazzola	Vicki	Nova Scotia Community College	vicki.gazzola@nscc.ca
Gouthro	Jennie	Hoskin	jgouthro@hoskin.ca
Grasty	Sarah	University of South Florida	grastys@mail.usf.edu
Greene	H. Gary	Moss Landing Marine Laboratories	greene@mlml.calstate.edu
Grehan	Anthony	National University of Galway, Ireland	anthony.grehan@nuigalway.ie
Gullage	Lauren	Memorial University of Newfoundland	lauren.gullage@mun.ca
Harris	Peter T.	GRID–Arendal	peter.harris@grida.no
Hendry*	Jonathan	National Oceanography Centre	jh25g13@soton.ac.uk

Last name	First name(s)	Organization	E-mail
Herder	Erin	Memorial University of Newfoundland	erin.c.herder@gmail.com
Hommeyer	Matthew	University of South Florida	mhommeyer@mail.usf.edu
Haulsee III	Ken	University of Delaware	khaulsee@udel.edu
Ierodiaconou	Daniel	Deakin University	daniel.ierodiaconou@deakin.edu.au
Jakobsen	Frank	Norwegian Geological Survey	frank.jakobsen@ngu.no
Jerosch	Kerstin	Alfred Wegener Institute	kerstin.jerosch@awi.de
Juteau	Jean-Philippe	Maritime Way Scientific	jpjuteau@maritimeway.ca
Kaskela	Anu M.	Geological Survey of Finland	anu.kaskela@gtk.fi
Keith	David	Fisheries and Oceans Canada	david.keith@dfo-mpo.gc.ca
Kenchington	Ellen	Fisheries and Oceans Canada	ellen.kenchington@dfo-mpo.gc.ca
Kentner	Victoria	NOAA Fisheries, USA	victoria.kentner@noaa.gov
Koop*	Leo	Delft University of Technology	l.koop@tudelft.nl
Kotilainen	Aarno T.	Geological Survey of Finland (GTK)	aarno.kotilainen@gtk.fi
Kraeutner	Paul	Ping DSP Inc.	paul@pingdsp.com
Kruss	Aleksandra	Istituto di Scienze Marine, Consiglio Nazionale delle Ricerche Arsenale, Italy	aleksandra.kruss@ve.ismar.cnr.it
Kurvinen	Lasse	Parks and Wildlife Finland	lasse.kurvinen@metsa.fi
Lacharité	Myriam	Nova Scotia Community College	myriam.lacharite@nscc.ca
Laferriere	Alix	Blackfoot Research, New Zealand	alixlaferriere12@gmail.com
LaFrance Bartley	Monique	University of Rhode Island Graduate School of Oceanography	mlafrance@uri.edu
Le Bas	Tim P.	National Oceanography Centre	tlb@noc.ac.uk
Lecours	Vincent	University of Florida	vlecours@ufl.edu
Leingang	Paul	University of Delaware	leing@udel.edu
Lightfoot*	Paula	Newcastle University School of Marine Science and Technology	p.lightfoot@newcastle.ac.uk
Lirette	Cam	Fisheries and Oceans Canada	cam.lirette@dfo-mpo.gc.ca
Masetti	Giuseppe	University of New Hampshire	gmasetti@ccom.unh.edu
McClinton	Tim	DEA Marine Services	tmcclinton@deainc.com
McCormack	Beth	Nova Scotia Community College	beth.mccormack@nscc.ca
McKee	Anne	Dalhousie University, Canada	anne.mckee@dal.ca
Miles	Lara L.	Memorial University of Newfoundland	laralmiles@gmail.com
Mireault	Callum	Memorial University of Newfoundland	camireault@mun.ca
Misiuk	Benjamin	Memorial University of Newfoundland	bmisiuk@mun.ca
Mitchell	Garrett A.	Fugro Marine GeoServices, Inc., Texas	gmitchell@fugro.com
Moody	Scott	MosaicGeo	scott@mosaicgeo.com
Moore	Danielle	Dalhousie University	daniellemoore@dal.ca
Murillo-Perez	Javier	Fisheries and Oceans Canada	javier.murilloperez@dfo-mpo.gc.ca
Neville	Danny	QPS	Neville@qps.nl
Nicholson	Jeremy	Teledyne CARIS, Inc.	Jeremy.Nicholson@Teledyne.com
Norton	Ashley R.	University of New Hampshire	anorton@ccom.unh.edu
Novaczek	Emilie	Memorial University of Newfoundland	enovaczek@mun.ca
O'Meara	Michele	US Geological Survey	momeara@usgs.gov
Quas	Lauren	University of Southern Mississippi	Lauren.Quas@usm.edu
Pallentin	Arne	National Institute of Water and Atmospheric Research	arne.pallentin@niwa.co.nz
Pearman*	Tabitha R.R.	National Oceanography Centre	t.r.r.pearman@soton.ac.uk
Pegg	James	Fisheries and Oceans Canada	james.pegg@dfo-mpo.gc.ca
Peyton	Derrick	IIC Technologies	derrick.peyton@iictechnologies.com
Pilegard	Timothy	University of Delaware	pilegard@udel.edu
Prampolini	Mariacristina	Istituto di Scienze Marine-Consiglio Nazionale delle Ricerche Sezione di Geologia Marina di Bologna	mariacristina.prampolini@bo.ismar.cnr.it

Last name	First name(s)	Organization	E-mail
Price*	David M.	National Oceanography Centre	d.m.price@soton.ac.uk
Proietti	Raffaele	Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA)	raffaele.proietti@isprambiente.it
Propp	Claudia	Federal Maritime and Hydrographic Agency, Germany	claudia.propp@bsh.de
Ramsay	Peter	Hypack	peter.ramsay@xyleminc.com
Reshitnyk	Luba Y.	Hakai Institute, Canada	luba.reshitnyk@hakai.org
Robert	Katleen	National Oceanography Centre	katleen.robert@noc.ac.uk
Rossiter*	Tom	National University of Ireland Galway and the Marine Institute	tom.rossiter@marine.ie
Rowden	Ashley A.	National Institute of Water and Atmospheric Research	ashley.rowden@niwa.co.nz
Ryan	Barry	Fugro Marine GeoServices, Inc.	barry.ryan@fugro.com
Sameoto	Jessica	Fisheries and Oceans Canada	jessica.sameoto@dfo-mpo.gc.ca
Sarty	Matthew	Clearwater Seafoods, Canada	mattsarty@clearwater.ca
Schiele	Kerstin	Leibniz Institute for Baltic Sea Research	kerstin.schiele@io-warnemuende.de
Schoening	Timm	Helmholtz Centre for Ocean Research	tschoening@geomar.de
Smith	Mark	AML	mark.smith@amloceanographic.com
Sowers	Derek	National Oceanographic and Atmospheric Administration	derek.sowers@noaa.gov
Steenstrup	Jens	R2 Sonic	jens@r2sonic.com
Stephens	Drew	ESRI, California	dstephens@esri.com
Stewart	Heather A.	British Geological Survey	hast@bgs.ac.uk
Szefler	Kazimierz	Maritime Institute in Gdańsk	kaszef@im.gda.pl
Taillefer	Martin	Maritime Way Scientific	mtaillefer@maritimeway.ca
Thorsnes	Terje	Norwegian Geological Survey	terje.thorsnes@ngu.no
Todd	Brian J.	Geological Survey of Canada	brian.todd@canada.ca
Vallius	Henry	Geological Survey of Finland	henry.vallius@gtk.fi
Van Lancker	Vera	Royal Belgian Institute of Natural Sciences	vera.vanlancker@naturalsciences.be
Viitasalo	Markku	Finnish Environment Institute (SYKE)	markku.viitasalo@ymparisto.fi
Virtanen*	Elina A.	Finnish Environment Institute (SYKE)	elina.a.virtanen@ymparisto.fi
Ward	Larry	University of New Hampshire	lgward@ccom.unh.edu
Webster	Timothy L.	Nova Scotia Community College	timothy.webster@nscc.ca
Wessels	Peter	Dalhousie University	peter.wessels@dal.ca
Westington	Meredith	NOAA	meredith.westington@noaa.gov
Wiktor Jr	Józef	Institute of Oceanology, Polish Academy of Sciences, Poland	wiktor@iopan.gda.pl
Yin	Ping	China Geological Survey	pingyin@fio.org.cn
Young	Mary	Deakin University	mary.young@deakin.edu.au

Risk Assessment of Coastal Alteration Effects on Fish Habitat Suitability Under Current and Future Climates

S. Abdel-Fattah[1], S.E. Doka[1], C.K. Minns[2]

1. Fisheries and Oceans Canada, Burlington, Ontario, Canada
2. University of Toronto, Ontario, Canada

Within fisheries science and coastal development, there has been a need for methods, models and tools for assessing project effects on fish habitat and for evaluating potential for offsetting of these impacts. For this reason we have developed The Habitat Ecosystem Assessment Tool (HEAT). This tool is an application of a quantitative fish habitat assessment for use in evaluating proposals (such as infills) affecting lacustrine fish. We have developed relationships that use fish lists, guild assignment, guild weighting as well as their thermal and habitat requirements to build a habitat suitability matrix (HSM) to estimate the habitat suitability indices along with the rules and criteria that must be applied to allow evaluation of fish habitats. The HSM model uses pooled matrices representing the aggregate habitat preferences of species by life stage to ensure that all needs during that critical stage are met for survival for each species. Using this data we can perform pre- and post-project assessment of limnological and physical habitat changes and their impact on fishes through scenario-testing. We have also tested climate driven variables such as water levels and temperature scenarios in the existing assessment to address changing depths that occur with climate change.

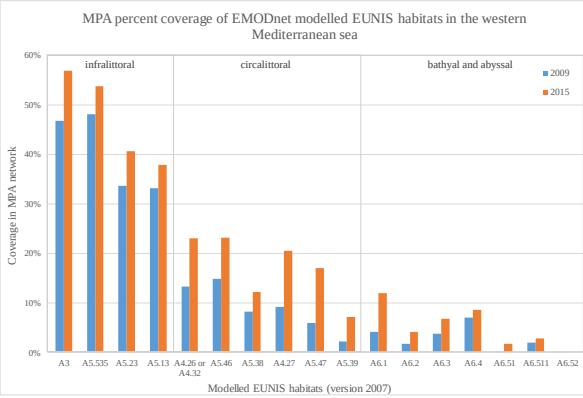
Applying Modelled Broad Scale Habitat Maps in MPA Network Evaluations - the Western Mediterranean Sea Case Study

S. Agnesi[1], A. Annunziatellis[1], G. Mo[1], J. Reker[2]

1. Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), Italy
2. European Environment Agency (EEA), Denmark

Over the last decades global, European and regional policy drivers have called on countries to establish networks of marine protected areas (MPAs) as instruments for protection of marine biodiversity. These policies also require the evaluation of the exerted protection effort against specific criteria (e.g. coverage) and targets with respect to the extension of marine biodiversity elements, such as marine habitats. A pan-European map presenting the distribution of modeled broad scale seabed habitats has been recently made available through the EMODnet project[1].

The present case study illustrates the usefulness of the EMODnet habitat map in evaluating the 2009–2015 trend in MPA network coverage of seabed habitats in the north-western Mediterranean Sea. An MPA network layer, containing sites whose protection objectives include benthic habitats, was created by querying the 2009 and 2015 versions of the following reported cartographic databases: (i) European inventory of nationally designated areas – CDDA; (ii) Natura 2000; (iii) Barcelona convention SPAMIs. All sites were merged and dissolved to avoid overlaps in the MPA layer. Extraction of the modeled habitat surface areas contained in the network was analyzed for each year against the coverage targets advocated by the Convention on Biological Diversity and the EU Habitats Directive. There is decreasing habitat coverage in the network as depth progresses and bathyal and abyssal habitats fall below of the 10% coverage (see figure). This trend can be attributed to the limited deep sea protection objectives of some of the environmental policies. All of the infralittoral and most circalittoral habitats reached the 10% target by 2015 while only half of the circalittoral habitats reached the 20% target by 2015.



[1] http://www.emodnet-seabedhabitats.eu/

An Object-Based Seafloor Classification Tool Using Recognition of Empirical Angular Backscatter Signatures

E. Alevizos[1]

1. GEOMAR Helmholtz-Centre for Ocean Research Kiel, Germany

This study presents a novel concept of seafloor acoustic mapping utilizing the angular dependence of high density soundings. A prerequisite is that data should result from a backscatter-dedicated survey (>100% swath overlap) in order to obtain small-scale seafloor areas ensonified from multiple incidence angles. Accordingly, backscatter data should be geometrically and radiometrically corrected in order to represent only variations due to seafloor type. This method is considered as a mixture of OBIA with empirical ARA and pattern recognition concepts and it provides supervised classification based on empirical backscatter angular signatures of a known set of seafloor types. Therefore it requires a library with all angular signatures corresponding to ground truth locations (seafloor type, dB and angle). The backscatter only needs to be stable and hence this approach is not only applicable on calibrated sonars but works for any MBES system that records backscatter in a stable way. The library should consist of sediment samples, underwater images and/or video which are used to drive the classification and validate its results. Ideally, the ground truth set should cover all different seafloor types from the study area. The concept is that angular backscatter signatures of known seafloor types that have been extracted from fine square areas of seafloor can be utilized for comparison with angular signatures of unknown seafloor. Initially, the study area is segmented into fine squares within which soundings from various beam-angles fall. The smaller the square size, the higher the seafloor homogeneity can be achieved; hence more representative angular backscatter signatures can be extracted for each seafloor type. In this study 5x5 m squares were used for representing naturally homogeneous seafloor. By extracting the angular signatures from the vicinity of sediment sample locations it was possible to use them as reference vectors for performing supervised classification. The classification works in the following way: vectors carrying the mean backscatter value per swath angle are being created from each group of soundings belonging to the same square. Following, each vector is compared to the reference vectors that represent ground-truthed seafloor types. The comparison tests whether the backscatter values of the vector under-comparison fall within a user-defined envelope (range of values) above and below the mean backscatter values of the reference vectors. If the backscatter values for the majority (>85%) of corresponding swath angles belong to the envelope of a reference vector, then these soundings are assigned with the class number of the reference vector. Empirical ARA is more flexible in describing seafloor heterogeneity, compared to physical backscatter models, therefore allowing for classification of a wider variety of seafloor types in a consistent way.

Merging AUV-Based Multibeam and Image Data to Map the Small-Scale Heterogeneity of Mn-Nodule Distribution

E. Alevizos[1], T. Schoenning[1], K. Köser[1], M. Snellen[2, 3], J. Greinert[1]

1. GEOMAR Helmholtz-Centre for Ocean Research Kiel, Germany
2. Acoustics Group, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
3. Deltares, Utrecht, The Netherlands

AUVs offer the unique possibilities for exploring the deep sea seafloor in high resolution over large areas. We highlight the results from AUV-based multibeam echosounder (MBES) bathymetry / backscatter and digital imagery from the DISCOL area acquired during SO242 in 2015. AUV bathymetry reveals a morphologically complex seafloor with rough terrain in seamount areas and low-relief variations in the Mn-nodule covered sedimentary abyssal plain. Backscatter provides valuable information about the seafloor type and particularly about the influence of Mn-nodules on the response of the transmitted acoustic signal. Primarily Mn-nodule abundances were determined by means of automated nodule detection on AUV seafloor imagery and nodule metrics such as nodules/image and nodules/m2 were calculated automatically for each image allowing further spatial analysis within GIS in conjunction with the acoustic data. AUV-based backscatter was clustered using both raw data and corrected mosaics.

In total two unsupervised methods and one machine learning approach were utilized for backscatter classification and Mn-nodule mapping. Bayesian statistical analysis was applied to the raw backscatter values resulting in six acoustic classes. In addition ISODATA clustering was applied to the backscatter mosaic and its statistics (mean, mode, 90th and 10th quartile) suggesting an optimum of six clusters as well. Part of the nodule metrics data was used together with bathymetry, derivatives (slope, rugosity, BPI, concavity) and backscatter statistics for predictive modelling of the Mn-nodule density using random forests. Results show that acoustic classes, predictions from random forest modelling and image-based nodule metrics show very similar spatial distribution patterns with acoustic classes hence capturing most of the local Mn-nodule variability. A strong correlation of nodule occurrence with mean backscatter, fine scale BPI and concavity of the bathymetry can be seen; backscatter classes reveal a gradient of decreasing nodule occurrence in N-S direction which is also evident in AUV imagery. These observations imply that nodule abundances are affected in general terms by local micro-bathymetry in a way that is not yet fully understood. However it can be concluded that nodule abundances can be sufficiently analysed by means of acoustic classification and multivariate predictive mapping which allows predicting the spatial occurrence of Mn-covered areas as important habitat in the deep sea in a much more robust way than previously possible.

Submerged Channels of the Eastern Brazilian Continental Shelf: Can the Slope Value be used as Potential Surrogates of Reef Environments?

T.C.M. Araújo[1], J.M.R. Camargo[1], B.P. Ferreira[1], M. Maida[1]

1. Federal University of Pernambuco (UFPE), Brazil

The Eastern Brazilian Continental Shelf (EBCS) is narrow, shallow and predominantly covered by biogenic sediments. Bathymetric surveys have revealed the common occurrence of submerged channels, related to the largest watersheds in the region and probably carved during periods of marine regression. With its break located between 40 and 80 metres deep, the EBCS was subjected to sub-aerial erosion for long periods, which justifies the occurrence of these erosive features related to continental drainage.

Based on a DEM with spatial resolution of 10 metres, the slope values of a section of the continental shelf of the state of Pernambuco were extracted. This initiative indicated an average slope value of 0.38°, consistent with that expected for a continental shelf. However, along the edges of three submerged channels the slope is more pronounced, with values generally between 3 and 45°. Therefore, in order to verify the characteristics of these steep reliefs, 03 video-transects were performed in two sectors of the Zieta Channel with a GoPRO 3 Black. Video-transects I and II were situated about 18 kilometres off the coast, while video-transect III was about 30 kilometres.

The data analysis involved the integration of the three parameters: substrate, geomorphology, and biota. The seascapes in each video-transect were defined such as: predominant, secondary or occasional. The record of combinations of substrate characteristics, geomorphology and biota occurrences also contributed to the definition of an associative pattern between the physical characteristics and the biological assemblages recorded.

Extreme values of slope (20–45°) are related to seascapes dominated by large rocky outcrops, cut by small channels and with relative structural complexity, as well as fish, sponges, algae and corals. On the other hand, values of slopes between 3 and 8°, composed seascapes dominated by small rocky outcrops, with irregular surface, usually covered by algae, and seascapes dominated by sub-outcrops, associated with rocky bottoms, sponges and corals. The flat reliefs (0–3°), related to the thalweg, harboured seascapes dominated by unconsolidated substrates, with bioturbation and occurrence of dense spots of algae of the genus *Halimeda*.

From these preliminary results, it can be suggested that the slope presented potential to be considered a surrogate for seascapes dominated by consolidated substrates and associated reef environments. This potential should be better investigated through new video surveys, contributing greatly to the consolidation of this relationship between slope, seascapes and benthic habitats, which, in turn, may guide the most appropriate design of Marine Protected Areas, as well as management measures of their fishing resources.

Application of Habitat Mapping to Coastal Aquaculture Research: Case Studies from Eastern Canada

J. Barrell[1], A. McKee[1], F. Bravo[1], C. Giroux[1], J. Grant[1]

1. Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada

Management of marine finfish aquaculture requires high-quality spatial data to address interactions with local ecosystems, including aspects of both biological communities and ecosystem function. Understanding of the spatial distribution of effects is critical for the implementation of marine spatial planning (MSP), where human activities are spatially managed to ensure sustainable use of resources. Conceptual and technological advances in habitat mapping have greatly increased the availability of marine spatial data, facilitating advances in several areas of aquaculture research.

Multiple case studies will be presented highlighting the use of spatial habitat data for aquaculture research, ranging from local to bay-scale investigations. Particular focus will be given to various methods of spatial data collection, including single-beam acoustics as well as optical data from satellites and UAVs. Mapping data is used alongside oceanographic data and model outputs to scale biogeochemical processes (e.g. benthic nitrogen cycling) in aquaculture areas. Substrate maps are also used to estimate habitat use around aquaculture sites by important wild species such as American lobster (*Homarus americanus*) and Atlantic salmon (*Salmo salar*). Spatial data also provide critical information for the management of fish health through epidemiological models of disease and pathogen transmission, crucial for ensuring sustainable aquaculture development in the marine environment. Implications for future MSP efforts in Nova Scotia and Eastern Canada will be discussed along with plans for future research activities in the aquaculture sector.

Submerged Marine Habitat Mapping, Cape Cod National Seashore: A Post-Hurricane Sandy Study

M. Borrelli[1, 2], E. Shumchenia[3] C.G. Kennedy[1], B.A. Oakley[4], J. B. Hubeny[5], H. Love[5], T.L. Smith[2], B. Legare[2], S. McFarland[1], S. Fox[6], G.S. Giese[2]

1. University of Massachusetts, Boston, Massachusetts, USA
2. Center for Coastal Studies, Provincetown, Massachusetts, USA
3. E&C Enviroscape, Rhode Island, USA
4. Eastern Connecticut State University, Connecticut, USA
5. Salem State University, Massachusetts, USA
6. Cape Cod National Seashore, Massachusetts, USA

Coastal storms are the primary drivers of coastal change, but submerged areas historically have been difficult to map and consequently to document change. Hurricane Sandy had a dramatic impact along coastal areas in proximity to landfall in late October 2012 and those impacts have been well-documented in terrestrial coastal settings, however, due to the lack of data on submerged marine habitats similar studies have been limited. One of the motivations for this study was to provide park managers with a baseline inventory of submerged marine habitats to measure change during future storm events.

A three-year study to map submerged habitats in Cape Cod National Seashore was recently completed. This was one of four contemporaneous studies that developed maps of submerged shallow water marine habitat in and around coastal national parks along the east coast of the United States. These four projects used similar methods of data collection, processing and analysis for the production of benthic habitat maps. Data from a phase-measuring sidescan sonar, bottom grab samples, seismic reflection profiling, and sediment coring we all used to develop submerged marine habitat maps using the Coastal and Marine Ecological Classification Standards (CMECS) in Cape Cod National Seashore.

Over 76 vessel-based acoustic surveys were conducted in extreme shallow water, across four embayments from 2014–2016. Sidescan sonar imagery totaling 83.1 km^2 were collected and within that area 61.3 square kilometres of collocated bathymetric data were collected with a mean depth of 4.6 m. Bottom grab samples (n = 476) and ancillary data were collected, macroinvertebrates were identified and used within the CMECS framework along with the geophysical and coring data to develop final habitat maps.

Using Autonomous Underwater Vehicles (AUVs) to Map the Fjordic Habitats in the Chilean Patagonia: A Tool for the Development of Marine Protected Areas

K.L. Boswarva[1], J.A. Howe[1], C. Fox[1], C. Abernethy[1], K.E. Brown[2]

1. Scottish Association for Marine Science, Scottish Marine Institute, Dunbeg, Oban, Scotland
2. School of Engineering & Physical Sciences; Teaching and Learning, Heriot–Watt University, Edinburgh

The Chilean Patagonia is a sparse environment with approximately one million inhabitants over 240,000 square kilometres. It has one of the world's most expansive coastlines with 84,000 km of inlets, bays, fjords and channels. Recent interest from multiple stakeholders including marine renewables and salmonid fisheries has led to numerous infrastructural developments, increasing local populations and promoting economic growth. Chilean Patagonia is now the second largest exporter of salmonids in the world. The expansion of aquaculture farms into pristine waters and the impacts on native species is of high concern and signifies a need to manage the marine environment throughout Chile through mechanisms such as Marine Protected Areas. Current frameworks are restricted by the availability of physical and biological data. Due to remoteness and inaccessibility, limited underwater surveys have been conducted and the seabed is largely unmapped. The capabilities of unmanned systems allow access to these previously unreachable areas, enabling thorough recording of habitat and biological diversity. A Gavia Autonomous Underwater Vehicle (AUV) equipped with a 500 kHz Geoswath bathymetric sonar and high resolution colour camera will be deployed in multiple locations throughout Chilean Patagonia encompassing a suite of oceanographic conditions; from coastal to freshwater fjords. Data will be processed using Caris HIPS and SIPS to identify backscatter, bathymetry, slope and rugosity. The in-built camera aims to produce high quality images of quantitative and qualitative ecological data. This data combined with supervised classification methodology will be used to produce predictive habitat maps. These methods form a novel and innovative proxy for calculating large-scale spatial biodiversity and therefore a useful marine spatial planning tool, with global application.

Acknowledgements: This project "Abiotic indicators in Chilean Fjords" is funded by the Chilean Research Council and FONECYT.

Benthic Habitat Mapping and Sediment Nutrient Cycling in a Shallow Coastal Environment of Nova Scotia, Canada

F. Bravo[1], J. Grant[1], J. Barrel[1]

1. Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada

Sedimentary facies and benthic metabolism of subtidal sediments were studied in a relatively small, but historically active bay in Southern Nova Scotia, Canada.

Our study approach was based on the combination of benthic habitat mapping, field/lab experiments, and numerical models of sediment geochemistry. This approach provided an effective mean for ecosystem-scale assessments of key benthic processes (carbon recycling, denitrification, etc.). The distribution of bottom types and sediment properties was assessed using direct (grabs and core sampling) and remote (video and acoustic) sampling methods. The geo-referencing, classification, and interpolation of sediment properties (acoustic data, bathymetry, organic matter content, sediment porosity, etc.) allow to produce maps showing their spatial distribution, which instead served as input of numerical models oriented to predict carbon and nitrogen recycling rates at bay-scale. This approach become relevant given the commonly limited spatial and temporal resolution of biogeochemical measurements.

Results are discussed in regard to the implications for coastal management (maintenance of ecosystem functioning), and understanding of coastal biogeochemical cycles. Data quality and accuracy of spatially interpolated data was also evaluated, including their impacts on model predictions.

An Ecoregional Assessment of the North Atlantic

D. Broughton[1], P. Helaouet[1], G. Graham[1], M. Edwards[1]

1. Sir Alister Hardy Foundation for Ocean Science, The Laboratory, Citadel Hill, Plymouth, UK

The Continuous Plankton Recorder (CPR) survey is one of the longest running marine biological monitoring programmes in the world. Started in 1931 by Sir Alister Hardy, the survey uses mechanical samplers, which collect marine plankton on a moving band of silk, towed behind "vessels of opportunity". Today the CPR survey is operated by the Sir Alister Hardy Foundation for Ocean Science (SAHFOS), located in Plymouth, UK, and operates 21 sampling transects, at monthly frequency, across the global ocean. Uniquely, the CPR survey's methods of sampling and plankton analysis remain unchanged since 1948, providing a spatio-temporally comprehensive 70+ year record of marine plankton dynamics. SAHFOS monitors the pulse of the oceans through the plankton and contributes to the significant scientific effort that advises political decisions on a global scale.

Biannually, SAHFOS produces the Global Marine Ecological Status report, which provides a synopsis on the state of change in marine plankton dynamics in the world's oceans. As part of the AtlantOS project (https://www.atlantos-h2020.eu) and to make our data more discoverable, we undertook to translate the North Atlantic section of this report into an interactive web-based product. The primary motivation for this is to make the hardcopy visualisations provided in the Global Marine Ecological Status explorable to end-users, and the underlying data accessible by direct download.

The web project (http://192.171.193.51/sahfos_demo/web-viz.html) is based on a GeoServer instance, providing both base maps and geographic features. The application uses OpenLayers 3 to make WMS and WFS requests to GeoServer. Over the base map, we overlay 41 "CPR Standard Areas". These are approximately rectangular in the open ocean, but roughly conforming to the continental shelves inshore, and with coastlines constructed from NOAA's "Global Self-consistent, Hierarchical, High-resolution Geography". Users can select one or more areas and a date range, and the type of charts to be shown.

Upon selection, the corresponding vessel routes and sample locations are dynamically overlaid on the map and, at the same time, "heatmap" charts for the user-selected variables are displayed. The charts are generated purely in Javascript using Plotly.

Once displayed, the users may then choose to download any of the charts, or the data used to produce the charts as a spreadsheet.

In the future, we plan to add visualizations for all of SAHFOS's standard products, adding maps for monthly means of Phytoplankton Colour Index, Total Diatoms, Total Dinoflagellates, and Total Eyecount Copepods, with the ability to display these as an animation over time.

Setting the Stage for Multi-Spectral Acoustic Backscatter Research

C.J. Brown[1], J. Beaudoin[2], M. Brissette[3], V. Gazzola[1]

1. Applied Oceans Research Group, Nova Scotia Community College, Dartmouth, Nova Scotia, Canada
2. QPS Canada, Fredericton, Canada
3. R2Sonic, LLC, 5307 Industrial Oaks Blvd., Suite 120 Austin, Texas 78735 USA

The establishment of multibeam echosounders (MBES) as a mainstream tool in ocean mapping has facilitated integrative approaches towards nautical charting, benthic habitat mapping, and seafloor geotechnical surveys. The combined acoustic response of the seabed and the subsurface can vary with MBES operating frequency. At worst, this can make for difficulties in merging results from different mapping systems or mapping campaigns. At best, however, having observations of the same seafloor at different acoustic wavelengths allows for increased discriminatory power in seabed classification and characterization efforts. Here, we present results from early trials of a multispectral multibeam system (R2Sonic 2026 MBES) in the Bedford Basin, Nova Scotia. In this system, the frequency can be modified on a ping-by-ping basis, which can provide multi-spectral acoustic measurements with a single pass of the survey platform. We demonstrate how this capability provides improved seafloor discrimination at this site based on the different frequency responses and seafloor sediment characteristics. These innovations offer tremendous potential for application in the area of seafloor geological and benthic habitat mapping.

A 165-km Long High-Resolution Bed-Sediment Classification of the Colorado River in Glen, Marble and Grand Canyons Using Multibeam Acoustic Backscatter

D. Buscombe[1], P.E. Grams[2], M.A. Kaplinski[1], R. Tusso[2], M. Yard[2]

1. School of Earth Sciences & Environmental Sustainability, Northern Arizona University, Arizona, USA
2. U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring & Research Center, Flagstaff, Arizona, USA

High-resolution multibeam backscatter and bathymetry have considerable utility for remote characterization of bed-sediment in a range of aquatic environments. Acoustic sediment classification techniques are being used in large rivers for the purposes of sediment budgeting, studies of sediment transport and hydraulics, and physical habitat characterization.

High-resolution (25-cm grid) maps of bed sediment have been constructed for an almost continuous 165-km stretch of the Colorado River in Glen, Marble and Grand Canyons using multibeam backscatter and bathymetry data collected with a Reson 7125 multibeam echosounder operating at 400-kHz. The data were collected over a four-year period (2012, 2013, 2014, and 2016) in modal water depths of between 2 and 15 m (maximum depth around 30 m). The bed of this large canyon river is various among sand, gravel, cobbles, boulders and submerged vegetation. The mapped riverbed consists of two long reaches with different character: 1) a 24-km reach of bed dominated by gravel- and cobble-supported submerged aquatic vegetation, and 2) a 161-km reach of mixed sand-gravel-cobble-bedrock riverbed with little to no vegetation. A 3-part substrate classification has been developed for Reach 1, and a 5-part classification for Reach 2. The sediment classifications are developed and calibrated to an extensive underwater video dataset collected with camera systems developed in-house by the USGS Grand Canyon and Monitoring Research Center.

Acoustic backscatter (target) strengths are computed by balancing a standard interfacial form of the active sonar equation, accounting for angular effects, transmission losses, system gains, attenuation by suspended sediment and (supra-beam-scale) slope effects in calculation of beam footprints. Owing to the small beam footprints of this high-frequency system operating in very shallow water, and the large variety of roughness scales present in the bed, local slopes are no longer small compared to the beam and pulse lengths. Therefore residual effects of small-scale topography contaminate the backscatter signal. A novel approach has therefore been developed to ameliorate the effects of sub-beam-scale micro-topographic effects on backscatter.

Significant changes in the composition of the abiotic component of sediment (such as homogeneous sand to homogeneous gravel) tend to occur over larger ('patch') spatial scales than caused by small- (or 'morphological') scale bedform topography (ripples, dunes, bars, etc) or biota (principally aquatic vascular plants and periphyton). These morphological contributions to backscatter are removed by frequency-domain filtering. Coherent scales between high-resolution topography and backscatter are identified using co-spectra, which are used to design frequency domain filters that decompose backscatter into two scales: the (unwanted) high-pass component associated with morphologies (ripples, dunes, bars or small vegetation patches), and the (desired) low-frequency component associated with the composition of superimposed sediment patches. This process results in considerably stronger relationships between backscatter strength coefficients and sediment composition.

A simple probabilistic (Gaussian Mixture Model) approach has been adopted for accurate classification of heterogeneous sediment at decimetric resolution. The approach is conceptually simple, and computationally efficient, therefore highly transferable from similar freshwater to marine systems consisting of rough sedimentary surfaces in shallow water.

Multibeam Water Column Filtering Methods to Improve Data Management and Bio-Acoustic Interpretation

I. Church[1], A. Greer2, L. Quas[2], M. Williamson[2]

1. University of New Brunswick, Fredericton, New Brunswick, Canada
2. University of Southern Mississippi, Stennis Space Center, Mississippi, USA

Water column acoustic return data from a 400 kHz Reson 7125 SV2 multibeam sonar was examined within the Mississippi Bight to identify and map biomass throughout the region. The multibeam sonar acoustic data are traditionally considered relative measurements of water column scattering or impedance contrasts, which are difficult to correlate directly with biological and physical properties of the water column. To overcome this constraint, the multibeam sonar data has been collected simultaneously with imagery from a towed profiling In Situ Ichthyoplankton Imaging System (ISIIS) (with CTD, dissolved oxygen, PAR, and chlorophyll-a fluorescence sensors). There are many technical challenges associated with correlating the two datasets, as the multibeam sonar data are in three dimensions, they provide outputs on different temporal and spatial scales, and the acoustic scattering patterns are challenging to identify and extract. Developing an efficient and robust filtering algorithm to identify biologically and physically dynamic areas of interest requires tackling issues with scattering artefacts, such as transmit and receive beam pattern effects and the patchiness of water column layers. The goal of this work is to correlate the sonar data to imagery data from the ISIIS, and other sensor information, expanding the potential applications of multibeam water column data to include identification of scattering features and examination of fine scale oceanographic processes.

CMECS Map for an Area of the Oregon Outer Continental Shelf Relevant to Renewable Energy

G.R. Cochrane[1], L.G. Hemery[2], S.K. Henkel[2], D.M.Schroeder[3]

1. U.S. Geological Survey (USGS), USA
2. Oregon State University (OSU), USA
3. Bureau of Ocean Energy Management (BOEM), USA

In 2014 the USGS and the BOEM entered into an Intra-agency agreement to map an area of the Oregon Outer Continental Shelf (OCS) off of Coos Bay, Oregon under consideration for development of a floating wind energy farm. The BOEM requires seafloor mapping and site characterization studies in order to evaluate the impact of seafloor and sub-seafloor conditions on the installation, operation, and structural integrity of proposed renewable energy projects, as well as to assess the potential effects of construction and operations on archaeological resources. The mission of the USGS is to provide geologic, topographic, and hydrologic information that contributes to the wise management of the Nation's natural resources and that promotes the health, safety, and well-being of the people.

For the Oregon OCS study the USGS acquired multibeam echo sounder (MBES) and seafloor video data surrounding the proposed development site, a 95 km2 area 15 miles offshore of Coos Bay, Oregon. The USGS subsequently produced a bathymetry digital elevation model and backscatter intensity grids. Analysis of the video data was conducted by OSU and a Coastal and Marine Ecosystems Classification Standard (CMECS) geoform and substrate component interpretation of the MBES data was conducted by the USGS.

Though combinations of mud and sand dominate the surficial substrate there is a diverse assortment of geomorphologic features related to geologic processes. Video supervised numerical analysis of the MBES backscatter intensity data and vector ruggedness derived from the MBES bathymetry data was used to produce a substrate model for the study area called a seafloor character raster. The sea floor character raster consists of three substrate classes, soft-flat areas, hard-flat areas and hard-rugged areas that were used to generate CMECS substrate attributes. For substrate polygons that had video grain size information a finer level of CMECS grain size was added to the map. CMECS geoform attributes were produced using depth, slope and benthic position index classes to delineate geoform boundaries. Seven geoforms were identified in this process including ridges, slump scars, slump deposits, basins and pockmarks. There is one anticlinal ridge where bedrock is exposed, a slump and associated scarps, and pockmarks. Pockmarks are seen in the form of fields of small pockmarks (< 100 metres diameter), a lineation of large pockmarks with methanogenic carbonates, and areas of large pockmarks that have merged into larger variously shaped depressions. The slump appears to have originated at the pockmark lineation. Existing multichannel seismic data was examined to attempt to identify crustal faults associated with pockmark areas and lineations. Faults related to anticlines could be inferred by displacement of reflecting strata but structures related to pockmarks could not be resolved.

Statistical analysis of the video data for correlations between substrate, depth and biotic assemblages by OSU resulted in the identification of seven biomes, three hard bottom biomes and 4 soft bottom biomes. A biotope map was generated using the seafloor character raster and the substrate and depth values of the biomes. Hard substrate biotopes were small in size and were located primarily on the ridge and in pockmarks along the pockmark lineation. The soft bottom biotopes consisted of large contiguous areas delimited by isobaths.

Spectral Discrimination of Coral Reef Environment using Derivative Analysis

C. Cruz[1], A. Tamondong[1, 2], K.D. Ticman[1], G.A. Go[1], R. Peralta[1], M.V. Vergara[1], I.E. Cadalzo[1], A.J. Songcuan[1], R.R. Quides[1], A. Blanco[1, 2]

1. UP Training Center for Applied Geodesy and Photogrammetry (UP TCAGP), Philippines
2. Department of Geodetic Engineering, University of the Philippines Diliman, Philippines

Coral reefs are often called the 'rainforests of the sea' because they are among the most diverse and complex of all ecosystems. Coral reefs play a vital role in the coastal and marine ecosystem. The Philippines has the second largest coral reef area in Southeast Asia which is estimated to be about 26,000 square kilometres. It lies within the Coral Triangle or the Indo-Malayan Triangle, a centre of marine biodiversity. However, reefs today are facing a wide and serious threats. Most of the coral reefs in the world are potentially endangered, mainly because of the unsustainable human exploitation exacerbated by global climate change. Mapping of coral reefs provides information to support the protection, conservation and monitoring of this vulnerable benthic habitat. However, typical maps derived using remote sensing data only includes classification of benthic communities due to the high level of complexity and spatial heterogeneity of the coral reef environment. Thus, there is a need to examine the reflectance properties or the spectral response of the different bottom types to serve as a reference for the characterization of the features.

This study was conducted to identify spectral characteristics of various reef components by determining the wavelength bands in discriminating coral reef types which can aid in a high-resolution mapping of features. It also proposed a standardized methodology for field measurements of the different coastal habitats using a portable spectrometer in various sites of the Philippines. Spectral measurements of the different coral reefs were taken using the OceanOptics spectrometer unit with wavelength range of 200–1100 nanometres. The acquired spectral curves were divided into the following classes: live corals, dead corals, sand, dead coral with algae, coral rubbles, and bleached corals. Twenty-five in-situ spectral measurements for each sample were averaged and smoothed using the Savitzky–Golay algorithm. This method fits a least square polynomial curve in smoothing the data and is a function of filter size for the calculation of the curve equation, and the degree of polynomial to be used. After the smoothing process, the spectral properties of the measured benthic feature were evaluated using derivative analysis. This calculates the n-derivatives of the reflectance curves to identify the optimal wavelengths for spectral discrimination. Results showed that there are differences in the optical characteristics among the coral reef types which could be used to improve the accuracy of classification and an efficient aid in mapping corals in the country.

Distribution and Abundance of Native Marine Species and an Invasive Predator on Coral Reefs of Eleuthera, the Bahamas

A.C.D. Davis[1]

1. Oregon State University, USA

Ecosystem based management (EBM) is a holistic approach that uses species-specific data to guide management but also incorporates environmental factors such as habitat and human-caused effects. Instead of focusing on the species of interest in isolation, EBM focuses on the system as a whole in order to create a comprehensive plan that ensures sustainability of the entire system. Though EBM is more common in terrestrial systems, this it is becoming more popular in management of marine ecosystems.

The coral-reef ecosystem in the Bahamas has experienced severe stress in the last few decades. In addition to habitat degradation due to coral bleaching, overfishing, and disease, a predatory fish species invaded the region in the early 2000s. The Indo-Pacific red lionfish (*Pterois volitans*) has added insult to an already injured system by reducing densities of a variety of reef fishes, which in some cases leads to local extinction. If we wish to preserve diversity of coral-reef fishes, it is now more important than ever to have a comprehensive view of the local distributions and abundances of species of importance in order to manage and conserve the ecosystem effectively.

Here I present distribution and abundance maps of the southern edge of Eleuthera Island, the Bahamas, for commercially and economically important native species, as well as the invasive red lionfish. Previous datasets for this area are relatively depauperate and mostly limited to long-line catch and release of sharks, and time series data of large grouper for one or two isolated locations. By incorporating counts and observations from SCUBA surveys over multiple years with satellite derived bathymetry data, we can create a more comprehensive picture of the macrofauna of the region that will aid the Bahamian government to manage and conserve species of interest.

Preliminary data indicate that vector ruggedness measure (VRM), rugosity, slope of slope, and bathymetric position index (BPI) are important model variables for predicting lionfish distributions on reefs. Additionally, undersea observations suggest that lionfish learn to evade divers on shallow reefs and may avoid areas that may have high human traffic, such as reefs with mooring balls or close to harbours. These patterns indicate that locations of popular dive sites and distance from shore may also be informative variables for predicting the distribution of lionfish.

Drone Based Very-High Resolution Imagery Analysed with Geographic Object-Based Image Analysis: The Perfect Match for Mapping Intertidal Habitats?

M. Diesing[1], S. Archer[1], J. Bremner[1], T. Dolphin[1], A.-L. Downie[1], C. Scougal[1]

1. Centre for Environment, Fisheries and Aquaculture Science (Cefas), UK

Intertidal zones act as a natural buffer against storms and wave activity, and support rich assemblages of invertebrates and vertebrates, which have high economic, conservation and aesthetic importance. They are highly dynamic environments subject to constant change, while at the same time also threatened by anthropogenic stresses, including coastal development and habitat degradation. Mapping intertidal habitats and monitoring their temporal change due to natural processes and human activities is therefore important.

The challenges of mapping and monitoring the intertidal zone are numerous including access, remote locations, tides and the dangers which arise from these. Remotely Piloted Aircraft Systems, commonly known as drones, offer exciting new opportunities for studies on intertidal ecology and habitat mapping, as they allow access to areas which are otherwise difficult to reach, can be mobilised relatively quickly and collect imagery of the intertidal zone at spatial scales relevant to answer ecological research questions. Drones allow intertidal zone mapping at very high spatial resolution (0.5 – 5 cm) in the visual and near-infrared spectrum. Additionally, digital surface models can be generated using structure-from-motion. These highly resolved data mean that scene objects are much larger than the pixel size of the image. In this so-called H-resolution case, pixel-based image analysis methods become increasingly inefficient as they struggle to derive meaningful spectral signatures from real-world objects with high within-class spectral variability. Conversely, geographic object-based image analysis (GEOBIA) is well suited for analysing and classifying highly resolved imagery. In the GEOBIA approach, the imagery is initially segmented into discrete regions that are internally coherent and different from their surroundings (so-called image objects). Classification of these image objects is subsequently performed by making use of image object features, which might include object statistics on input layers, geometry (shape and size), texture, topology (e.g. relations to neighbouring objects) and others.

This contribution presents results of a two-year project investigating the applicability of GEOBIA to very-high resolution imagery collected with a fixed-wing drone over (i) a muddy intertidal zone in the East of England (Two Trees Island, Essex, UK) with the aim of mapping seagrass beds, and (ii) a rocky shore platform situated in the Bristol Channel (UK) mapped repeatedly to detect change in the cover of *Corallina sp.*, a red seaweed with a calcareous skeleton. We demonstrate that intertidal habitats can be mapped with high accuracy >90% (sensitivity, specificity, balanced accuracy) across all classes. For change detection, we use image datasets from two dates (T_1 and T_2). Initially, a habitat map is created for T_1 using the random forest algorithm. Segmentation on temporally stacked image data, followed by iterative trimming of outliers allows us to identify changed image objects in a statistically robust way. Subsequently, unchanged image objects of the T_1 map are used as 'samples' to predict habitat classes in the T_2 map. Post-classification change detection (T_1 vs T_2) allows definition of the direction of change (from-to). We show that the inclusion of these latter stages in the change detection methodology not only yields more information on the nature of change, but also improves the accuracy in change detection.

Regional-Scale Mapping of the Sediments and Biotopes of the Barents Sea Through Synthesis of Existing Data

M.F.J. Dolan[1], Aivo Lepland[1], Aave Lepland[1], L. Jørgensen[2], A. Rybalko[3], V.S. Lien[2], P. Ljubin[4]

1. Geological Survey of Norway (NGU), Norway
2. Institute of Marine research, Bergen, Norway
3. Federal State Unitary Research and Production Enterprise for Marine Exploration (SEVMORGEO), St. Petersburg, Russia
4. Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO), Murmansk, Russia

Knowledge of the distribution of seabed sediments, benthic communities and their associated environment (biotopes) provides important baseline information for sustainable management of the oceans. The Barents Sea comprises a vast area of continental shelf spanning international boundaries, where this type of information is in increasing demand for management related issues in these high-latitude waters. Synthesis of existing data originally obtained for other purposes can provide an important first step in making the required information available, as well as helping to identify areas where further mapping should be prioritised.

We present two related regional-scale maps recently generated for a large part of the Barents Sea continental shelf where varying amounts of existing data were available from Norwegian and Russian institutions: (1) a map showing the distribution of seabed surface sediments (1:3,000,000), and (2) a map showing the predicted distribution of benthic biotopes (4 km raster resolution) based on Random Forest modelling. The biotope map makes use of the sediment map as a key predictor variable, together with bathymetric, oceanographic and other environmental variables. Biotope classes are based on species composition as identified from benthic trawl samples.

Compilation and synthesis of geo-referenced data from various sources can produce valuable results but can also lead to uncertainties in the resultant map products which are important to convey to data users. To support our thematic maps we present a confidence assessment of the foundation datasets contributing to the sediment map. We also discuss further issues related to map confidence and scope for updating the maps as new data become available.

Quaternary Geological Features and Oceanographic Conditions Supporting Coral and Sponge Gardens in the Northern Labrador Sea and Baffin Bay

E. Edinger[1, 2], B. Neves[2, 3], V.E. Wareham[3], D.C. Campbell[4], S. Davin[5], O. Sherwood[6], C. Dinn[7], S. Dufour[2], C. Hillaire-Marcel[5], P. Archambult[8]

1. Geography Department, Memorial University of Newfoundland, Canada
2. Biology Department, Memorial University of Newfoundland, Canada
3. Northwest Atlantic Fisheries Centre, Fisheries and Oceans Canada, Canada
4. Geological Survey of Canada Atlantic, Natural Resources Canada, Canada
5. GEOTOP, Université de Québec à Montréal, Canada
6. Institute of Arctic and Alpine Research, University of Colorado, USA
7. Biological Sciences, University of Alberta, Canada
8. Département de Biologie, Université Laval, Canada.

Deep-sea corals and sponges are a diverse group of habitat-structuring organisms found at continental slope depths in most of the world's ocean basins. Their distributions are influenced by oceanographic parameters such as temperature and salinity at coarse scales, and by surficial and bedrock geology and intermediate and fine scales. Recent remotely operated vehicle (ROV) video surveys focusing on twelve cold-water coral and sponge habitat sites in the northern Labrador Sea and Baffin Bay, Canada, were accompanied by acquisition of multibeam sonar and sub-bottom profiles, enabling analysis of the geological features upon which the coral and sponge habitats have grown. CTD casts in the same locations gathered data on temperature, salinity, seawater density, nutrient concentrations, and calcium carbonate saturation state.

Most of the Northern Labrador Sea coral and sponge habitats are developed on glacially deposited materials. On the NE Saglek Bank, the site with the highest abundance of large gorgonian corals in the region, a diverse coral fauna occurs on current-swept bouldery gravels of glacial or glaciofluvial origin, with channels resembling glacial outwash fan channels between 300 and 400 m water depth. Further north in the Labrador Sea, near the Hatton Basin, SE Baffin shelf and slope, and Cape Dyer sites, diverse sponge-rich habitats appear to be most common on ice-contact bouldery gravels that have been extensively scoured by icebergs. On the outer side of the Hatton Basin sill, *Primnoa resedaeformis*-rich coral faunas are well developed on bouldery gravels that are interpreted as the grounding-line facies. CTD profiles at some of these northern Labrador Sea locations suggest sharp thermoclines associated with water mass boundaries, which likely also influence the distribution of the corals.

Dense *Keratoisis* sp. bamboo corals in SE Baffin Bay are developed on muddy bottoms overlying a trough-mouth fan in SE Baffin Bay. Although the bamboo corals baffle sediments, creating small-scale topography, the ridges observed in multibeam and sub-bottom profile are glaciomarine in origin, likely till-tongues or glacigenic debris flows.

Multibeam sonar and sub-bottom profiles were used to examine the geology of two sites with reported possible cold-seep related mounds, on the NE Saglek Bank and the SE Hatton Basin. Both sites are found within the iceberg-scoured ice-contact sediment facies. No evidence of authigenic carbonates or cold-seep related mounds was observed in multibeam sonar, sub-bottom profile, or box-core. Multibeam and sub-bottom profiles of the reported possible mound field in SE Hatton Basin revealed an iceberg-scoured ice-contact bouldery gravel facies, consistent with that observed at the NE Hatton basin sponge-dominated site. Methane bubbles and microbial mats were confirmed at a known hydrocarbon seep from Scott Inlet, in NW Baffin Bay. Bedrock exposures along cliffs in Scott Inlet support abundant *Cladorhiza* carnivorous sponges.

Diverse sponge gardens were found on rill-and-gully morphology glaciomarine gravelly sands in SW Baffin Bay. The species composition of these sponge gardens appears to be quite different from that found in the northern Labrador Sea and in Frobisher Bay. Both the coral and sponge gardens contribute to benthic biodiversity throughout the region.

Using a Commercial Drone for Mapping Ecological Phase Shifts on the Coral Reefs of Southern Faafu Atoll, Republic of the Maldives

L. Fallati[1, 2], F. Marchese[1], A. Savini[1, 2], C. Corselli[1], P.A. Zapata Ramirez[3], P. Galli[2, 4]

1. Department of Earth and Environmental Sciences, University of Milan – Bicocca, Milan, Italy
2. MaRHE Center (Marine Research and High Education Center), Magoodhoo Island, Faafu Atoll, Republic of Maldives
3. University of Granada
4. Department of Biotechnologies and Biosciences, University of Milan – Bicocca, Milan, Italy

The Republic of the Maldives is a Small Island Developing State with a unique geographic configuration: an archipelago composed of more than 1100 islands surrounded by coral reefs, grouped into a chain of atolls in the Indian Ocean. The one-metre elevation of most of the atolls' islands makes the Maldives one of the countries highly vulnerable to the impacts of climate change. Maldivian islands are carbonate landforms, totally composed of biogenic sediments produced by the surrounding coral reef. Healthy coral reefs are thus essential for the survival of the Maldivian islands due to their capacity to keep up with rising sea-level. Nevertheless, the Maldivian coral reefs are threatened by anthropic and climatic issues and during April and May 2016 they faced a massive coral bleaching followed by extremely high rates of mortality.

In our study, we collected high resolution images using a commercial drone (DJI Phantom 4) along different sector of reefs surrounding inhabited, uninhabited and resort islands of the Southern Faafu Atoll. The acquired data were processed in order to map the extension and the composition of shallow lagoons habitat, from the beach to the reef crest. Comparing these new results with habitat maps realized using satellite images databases from 2011 to 2016 (RapidEye, Sentinel 2 and LandSat8) and field data (snorkelling and diving transects), we were able to create habitat change maps and correlate these changes to environmental disturbances. In addition, high resolution images (1.5 cm/pixel) were collected in situ, at selected locations, in order to create a 3D model of shallow reef communities using structure from motion photogrammetry technologies. These 3D optical models will be used as the first step of a three year monitoring campaign designed to observe the 3D structural complexity changes of the reef after the 2016 bleaching event.

The whole study will focus on the integration of multi-scale maps to investigate, on a multi-temporal scale, ecological and geomorphological shifts in the study area and to figure out relationships with human activities (agriculture, land reclamation, new infrastructure) and pressures related to global climate change.

Cryptic or Simply Neglected Diversity?

D. Fiorentino[1], U. Gräwe[2], J. Holstein[3], J. Dannheim[3], K.H. Wiltshire[1], T. Brey[3, 4]

1. Alfred-Wegener-Institut Helmholtz Zentrum für Polar- und Meeresforschung, Coastal Ecology, List, Germany
2. Leibniz-Institut Institut für Ostseeforschung Warnemünde, Rostock, Germany
3. Alfred-Wegener-Institut Helmholtz Zentrum für Polar-und Meeresforschung, Bremerhaven, Germany
4. Helmholtz Institute for Functional Marine Biodiversity at the University of Oldenburg, Germany

The southern North Sea constitutes one of the best studied and data rich, but also most exploited marine areas globally. However, still we lack sufficient knowledge of core ecological features and processes, e.g., species distribution dynamics, environmental drivers, and their links. Although meaningful management requires knowledge of the spatial structure and variability of the systems, the traditional approach sees species handled together according to the concept of ecological communities. Consequently, the scientific "handling" of the linkage between environmental drivers and biota does neither consider nor test whether the targeted communities actually exist or are just artificial artifacts created by the classification process. Crisp classifications are used to identify and define "communities" adding the further limitation of correctly setting a community border that possibly does not exist. But how valid is this approach? This is the question we tackle here.

We analyse a large data set of about 1150 grab samples of benthic macrofauna collected in the German Bight. We applied fuzzy logic to provide an unsupervised classification of any degree of species association. Random Forest aided in mapping all degrees of species association and to shed light on their potential environmental drivers. Our approach overcomes the problem of crisp borders between communities. It classifies faunal associations in a continuous range from areas where one community can be well defined to areas where no community is distinguishable. One endpoint of this range is characterized by associations with highly structured interactions and dependency between species. The other endpoint is characterized by associations assembled by random processes.

The German Bight benthos displays the full range of association types. Regions where random association of species occurs show higher small-scale spatial variability, which indicates higher turnover rates than areas characterized by communities. These findings raise important questions for conservation strategies. Are these dynamic areas of higher "value"? How can conservation management account for a more complex spatial pattern as well as for the different turnover rates?

ATLAS: A Trans-Atlantic Assessment and Deep-Water Ecosystem-Based Spatial Management Plan for Europe

A.J. Grehan[1], J.M. Roberts[2], and the ATLAS Consortium[3]

1. National University of Ireland, Galway (NUIG), Ireland
2. University of Edinburgh (UEDIN), United Kingdom
3. http://www.eu-atlas.org (ATLAS), Europe

The ATLAS EU Horizon 2020 project, running from 2016 to 2020, has created a dynamic new partnership to assess the Atlantic's deep-sea ecosystems and Marine Genetic Resources and create the integrated and adaptive planning products needed for sustainable Blue Growth. ATLAS is gathering diverse new information on sensitive Atlantic ecosystems (including Vulnerable Marine Ecosystems (VMEs) and Ecologically or Biologically Sensitive Areas (EBSAs)) to produce a step-change in our understanding of their connectivity, functioning and responses to future changes in human use and ocean climate. Fully integrated spatial planning products built on basin and regional scales are needed to allow stakeholders to explore, and respond to, alternate scenarios of ocean dynamics and cross-sectoral Blue Growth.

The EU FP7 MESMA (Monitoring and Evaluation of Spatially Managed Areas) framework is being applied in case studies spanning the deep waters of the EU, US, Canada and ABNJs (NAFO and NEAFC regulatory areas) against the backdrop of potential climate change, to develop marine spatial planning scenarios to support basin scale ecosystem based management. Initial plans for each case study are presented.

Fit for Purpose Approaches to Seabed Mapping; Developing a Tool Box

S. Green[1], R. Cooper[1], M. Lark[1], D. Dove[1], H. Stewart[1]

1. British Geological Survey, UK

The British Geological Survey (BGS) is recognised as a national and international leader in characterising the geological nature of the seabed and shallow sub-seabed, from developing novel methodologies, to research and applied science. The BGS, often working together with academics and industry-based scientists, are perpetually active in innovating new data processing and interpretation techniques, including remote-sensing and statistical protocols, automatic feature-detection algorithms, and database solutions.

There is no one-size-fits-all approach for seabed mapping, and standardisation of the flow from multibeam echosounder (MBES) data to interpretation and map production, remains an elusive goal. Numerous factors must be considered in determining the most appropriate approach for substrate mapping. These include the planned end user, mapping objective, scale, data quality, and geological context. A crucial step in the mapping process is to take account of these variables, and determine the most suitable mapping methodology.

Considering these conditions, this study elucidates the decision-making process behind the selection of a mapping technique and illustrates the application of a variety of approaches to produce maps for a range of end users. The relative merits and caveats to these outputs are considered, with a particular focus on the requirements of different end users.

GeoHab's Role in the Presentation of Scientific Facts, A Global Challenge

H.G. Greene[1]

1. Tombolo Mapping Lab, Orcas Island, Washington, USA

Politics should never play a role in how scientific facts are determined and presented. Yet the so-called "alternative facts" have entered our lexicon from a political stage in the US and scientists around the world are scrambling to secure a voice that articulates what "facts" mean and how they are obtained. In general, science is under attack by politics. Although small and informal in comparison to other scientific organizations around the world, GeoHab is not immune from such attacks and scientists involved with GeoHab need to consider how to keep their organization scientifically pure with a strong voice of creditability. A brief review will be made on how GeoHab got where it is and the beneficial impacts made on the science of habitat and geologic mapping, and examples provided that illustrate the social and civil benefits of the organization and its scientists. A discussion will be made on what we see as the way forward and how GeoHab can put to rest the concept of "alternative facts".

Modeling Distributions of Cold-Water Corals in the Newfoundland and Labrador Region using MaxEnt

L. Gullage[1], E. Edinger[1, 2], R. Devillers[1]

1. Geography Department, Memorial University of Newfoundland, Canada
2. Biology Department, Memorial University of Newfoundland, Canada

Species distribution models (SDMs) are increasingly used in ecology and conservation to predict species distributions based on benthic habitat requirements. SDMs help when designing conservation approaches for regions lacking detailed data on species requiring protection; however, such approaches are limited by the quality of the training data, and by the modeling approaches used. In order to support the design of marine protected areas that can protect cold-water corals and sponges in the Newfoundland and Labrador region, Eastern Canada, we used MaxEnt to model the distributions of 19 coral species belonging to four functional groups: large gorgonians, small gorgonians, sea pens, and soft corals.

Coral distribution data from 2004–2011, obtained from the Department of Fisheries and Oceans Canada (DFO) multi-species trawl surveys, were used to generate SDMs. These data encompass the south coast of Newfoundland, the Grand Banks, the Flemish Pass, Northeast Newfoundland Shelf, and Labrador shelf to 60N. Environmental datasets used to generate models included: GEBCO bathymetry, six terrain attributes derived from bathymetry, bottom temperature and salinity, and surface chlorophyll A concentrations.

Modeled distributions predicted greatest coral abundance along the continental shelf break and upper slope throughout the region. When analyzed at the functional group level, large gorgonians were predicted to be most abundant off northern Labrador, off the central Labrador shelf, and in parts of the SW Grand Banks. Small gorgonian distributions were most concentrated along the Labrador Shelf break, the NE Newfoundland Shelf break, as well as along the shelf break of the SW Grand Banks. Sea pen distributions were greatest along the SW Grand Banks and the south coast, particularly within the Laurentian Channel. In contrast, soft corals were most abundant on the bank tops. Agreement between observed and modeled distributions was assessed using area under the curve (AUC), true skill statistics (TSS), and comparisons with independent datasets. Findings consistently illustrated high model accuracy (e.g. AUC >0.9).

Analysis of predicted distributions at the species level found large differences among species within functional groups, particularly among the large gorgonians. Results indicate that coral functional groups based on taxonomy do not group species sharing similar environmental preferences, and that SDMs should instead be performed on individual species of interest. Furthermore, previous models for the region based upon Random Forest modeling have predicted sponge and coral habitats extend into deep water areas of the continental rise. Our study does not confirm those predictions, and limited knowledge of the bathyal and abyssal depths in these regions do not suggest appropriate bottom types for these species. In contrast, our results predict coral distributions are concentrated along the continental slope and shelf break, having a high level of agreement with the training dataset, and with predicted global distributions of the same taxa. Our models suggest that conservation efforts for corals should be concentrated at the shelf-break and upper continental slope, where they are known to occur, rather than in deep-water areas where they might occur, and where there are fewer competing human uses than on the shelf break and upper slope.

Arctic Ocean Seafloor Geomorphic Features and Benthic Habitats – Relevance for Conservation and Marine Spatial Planning

P.T. Harris[1], M. Macmillan–Lawler[1]

1. GRID-Arendal, Arendal, Norway

The Arctic Ocean is geomorphically unique among ocean basins for its large percentage areas of continental shelf (51.8%), plateau (9.2%), spreading ridges (4.8%), shelf valleys (14.0%), submarine canyons (16.1%), and terraces (24.6%), all of which are greater in area proportionately compared with the earth's other ocean basins. It also is distinguished by its proportionately small areas of abyssal plains, escarpments and seamounts as well as the absence of any hadal zones or deep ocean trenches (Fig. 1). These observations are relevant to the distribution of benthic species and Arctic biogeography, because seafloor geomorphic features are surrogates for benthic habitats, at the relevant (broad) spatial scale.

Two categories of geomorphic feature can, in particular, be attributed to Pleistocene glaciation and the attendant export of sediment to the ocean basin: glacial troughs and submarine canyons. Glacial troughs characterize 24% of the Arctic shelf, second only to Antarctica where 40% of shelf area is glacial trough. Arctic submarine canyons are twice the size of those in non-polar regions. Canyons in the Arctic have an average size of 890 square kilometres compared to the overall (global) average size of 463 square kilometres. Canyons comprise an average of 11.2% of the continental slope area, attaining maxima of 16.1% of the continental slope of the Arctic Ocean. The larger size and greater fractional slope-area of Arctic canyons is attributed to glacial export of sediments into the Arctic Ocean during Pleistocene ice ages.

Conservation measures in the Arctic include the declaration of marine protected areas (MPAs) that are located mainly along the coasts and continental shelf areas of Arctic countries. This MPA configuration results in a lack of protection for categories of deep sea features such as submarine canyons, seamounts and spreading ridges, and the unique benthic ecosystems that inhabit them. As anthropogenic climate change causes a gradual decline in sea ice cover, previously inaccessible benthic habitats may become vulnerable, for the first time, to human exploitation (i.e. fisheries and oil and gas industries).

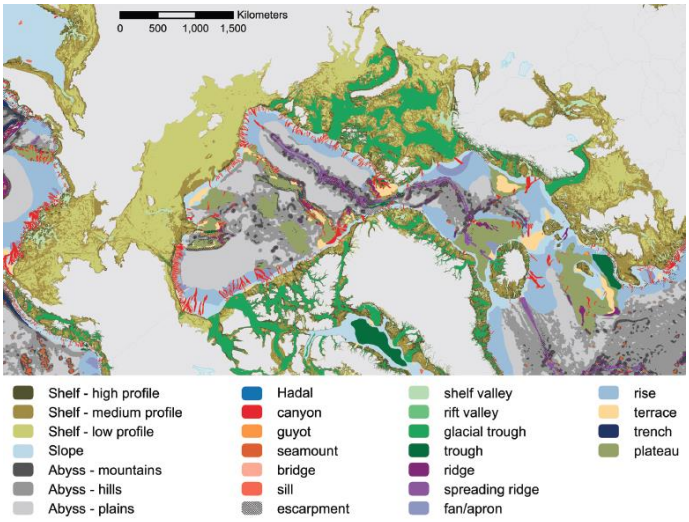


Figure 1. Geomorphic features of the Arctic Ocean (from Harris *et al*., 2014. Geomorphology of the oceans. Marine Geology **352**, 4–24).

Quantifying Macro-Scale Geomorphological Changes Post-Hurricane Sandy and Hurricane Joaquin at Assateague Island Utilizing Bathymetric Mapping Techniques

K. Haulsee III[1]

1. University of Delaware, USA

Assateague Island is a barrier island complex that stretches 37 miles along the Atlantic coast of Maryland and Virginia. The island's location along the eastern seaboard makes for a highly dynamic system that not only changes over long temporal scale through longshore transport and sea level transgression/ regression, but also over short seasonal scales due to strong currents and storm events such as Hurricane Sandy in late October 2012 and Hurricane Joaquin in October 2015. Geologically speaking, both hurricanes gave us a rare opportunity to quantify large spatial scale sea-floor changes over a short temporal scale because of the vast amount of energy that moved through the region in 2012 and 2015. This coastal geomorphological study will aim to quantify the macro-scale changes that took place over time by utilizing data collected via bathymetric sea-floor mapping surveys that took place in 2011 and 2014. The first data set was collected by the Maryland Geological Survey pre-Hurricane Sandy (2011), using a Versar single-beam echosounder. This will be compared to multi-phase bathymetric data that was collected by the University of Delaware utilizing an Edgetech 6205 multi-phase echosounder (2015). Comparing these two data sets allows us to measure large spatial scale changes over a short temporal scale. This will aim to quantify the amount of substrate changes and overall sediment movement based off each storm event. This study will have implications for quantifying near shore sand resource movement during storm events.

Scour Evolution Around a Vibrating Monopile in Cohesive Beds

J.A. Hendry[1], J.K. Dix[1], C.E.L. Thompson[1], R.J.S Whitehouse[2], J.M. Harris[2]

1. University of Southampton, National Oceanography Centre, UK
2. HR Wallingford, Howbery Park, Wallingford, Oxfordshire, UK

With the advent of Offshore Wind Farms (OWF), energy security of many countries has the potential to progress towards self-sustainability. Early stages of offshore turbine installation took place in nearby post transgressional shallow sands. These locations were preferentially developed given their relative ease of installation, maintenance and supportive knowledge of granular soils. Fuelled by increased power generation with larger scale, and concerns of noise pollution and displeasing aesthetics, more recent stages of OWF development are entering deeper water. Cohesivity is commonly encountered within these environments of fine grained soils and consolidated tills. With little knowledge of scouring implications these sites are often over engineered, from calculations based on parameters orders of magnitudes too conservative.

This paper will discuss offshore cohesive soils and the initiation of floc erosion at critical bed stresses defined through geotechnical analysis dictating the temporal evolution of scour. Moreover, this study examines the potential impact of vibration, which at present is unknown, but is hypothesised to provide a critical plane of weakness directly adjacent to the monopile.

Using ArcGIS and MATLAB the cohesive bed locations are assessed. By extracting field CPT obtained from BGS, and the Marine Data Exchange, seabed parameters are chosen. These parameters are then scaled to a flume located at the University of Southampton and 4D photometry adopted for analysis of the spatial and temporal variation of the scour geometry. We evaluate the degree to which the turbine excitation affects the structure stability of the emplaced monopile and compare the effect on the seafloor bathymetry. These results are evaluated relative to Offshore Wind Farm field studies in the UK and in the East China Sea.

Measuring Spatial and Temporal Benthic Community Change in Frobisher Bay, Southern Baffin Island

E. Herder[1], B. Misiuk[1], A. Aitken[2], E. Edinger[1, 3]

1. Department of Geography, Memorial University of Newfoundland, Newfoundland, Canada
2. Department of Geography and Planning, University of Saskatchewan, Saskatchewan, Canada
3. Department of Biology, Memorial University of Newfoundland, Newfoundland, Canada

Benthic communities may be significantly impacted by long-term change as a result of anthropogenic or natural stressors. Arctic coastal regions are particularly at risk as seasonal sea ice retreats and previously ice covered regions open. Characterizing marine faunal biodiversity in Arctic regions through predictive habitat mapping is a crucial step towards protecting sensitive Arctic marine ecosystems. Benthic habitat maps provide a snapshot of the existing biological and physical environment while also providing a baseline of knowledge for long-term monitoring. Resampling of historical sites in Frobisher Bay, a large macro-tidal bay in southern Baffin Island, offers a unique opportunity to study temporal and spatial change in benthic communities. Benthic infaunal samples were initially collected at twelve long-term ecology (LTE) stations using a grab sampler in inner Frobisher Bay from 1967–1976, providing seasonal and inter-annual benthic infaunal sample data for this region. In 2015 and 2016, the same LTE stations plus an additional eighteen stations were sampled nearby to a maximum water depth of 100 metres using a grab sampler, box core, and underwater towed video camera system. Benthic faunal samples and sediment samples collected for grain size analysis will be used to ground-truth multibeam bathymetry and backscatter data acquired between 2012 and 2016. Habitat maps produced from infaunal sample data will offer a visual depiction of current spatial community assemblages and allow for an assessment of spatial change based on historical infaunal community composition. This analysis will provide context for assessing temporal change in benthic communities in Frobisher Bay.

Polychaetous annelids were the dominant taxa observed at all stations sampled from 1967–1976. Other dominant taxa observed at stations near Iqaluit included oligochaetes, bivalves, and gastropods. Amphipods, ostracods and priapulids were observed at only a few of these stations in high densities. Ostracods were the second most dominant taxa at stations located to the south-east of Iqaluit. Amphipods, bivalves, cumaceans, pycnogonids, and tanaids varied among stations as the third most dominant taxon. Polychaetous annelids were dominant in the sorted 2016 benthic samples with amphipods, bivalves, gastropods, and ophiuroid echinoderms also present at all stations. Some stations near Iqaluit indicated the presence of isopods and ostracods while samples collected to the southeast of Iqaluit indicate the presence of ostracods, pycnogonids, shrimp, and bryozoan fragments. Towed video transects have been analyzed at four LTE stations. Two stations were dominated by tubiculous suspension-feeding polychaetes and ophiuroid echinoderms, however, different ophiuroid species were observed at each of these stations. One station was dominated by a red leafy macroalgae and ophiuroids and another station was dominated by a brown mat over the sediment along with the macroalgae *Agarum* sp. and *Laminaria* sp. Community structure analysis performed on the historical and new sample data will evaluate the extent of temporal change of benthic communities in inner Frobisher Bay.

Mapping Benthic Habitat and Fish Populations on the West Florida Shelf: Integration of Marine Acoustics and Towed Video Technologies

M. Hommeyer[1], S. Grasty[1], C. Lembke[1], S. Locker[2], J. Brizzolara[1], J. Gray[1], E. Hughes[1], A. Ilich[1], S. Murawski[1]

1. University of South Florida - College of Marine Science, St. Petersburg, Florida, USA
2. United States Geological Survey, St. Petersburg, Florida, USA

It has been demonstrated though hydrographic modeling that oil from the *Deepwater Horizon* blowout likely reached the West Florida Shelf (WFS) not long after the time of the incident in the spring of 2010. Fortunately, the majority of the benthic habitat on the WFS was less impacted than the ecosystems in closer proximity to the wellhead. However, the extensive impact of this event within the Gulf of Mexico underscored the need for more baseline data to better understand the potential impacts of any future oil spills. Robust assessment is difficult when the baseline condition of the resource is largely unknown. A gap analysis of coastal and marine data sets conducted in 2012 identified "benthic habitat" and "living marine resources" as the top two categories for which increased research in the eastern Gulf should be prioritized. Yet, only a small fraction of the seafloor on the WFS has been characterized at the spatial resolution achievable by contemporary instrumentation.

The Continental Shelf Characterization, Assessment and Mapping Project (C-SCAMP) is surveying areas on the WFS that are likely to contain essential habitat for reef fish and sea turtles. Multiple complementary technologies are employed in this effort, including multibeam and split-beam echosounders as well as a towed camera system. As of the end of this project's first full field season (2016), ultra-high resolution bathymetry and co-registered acoustic backscatter data has been collected for over 800 square kilometres of seafloor, and more than 80 hours of imagery has been recorded.

Preliminary results of the benthic habitat analyses and fish assessments for selected areas will be presented. Many of the areas mapped by C-SCAMP have been found to contain extensive hard bottom communities and support high reef fish abundance and diversity. The overall aims of the project and other areas of research will also be briefly discussed, including benthic faunal analysis and the synthesis of water column data from the split-beam echosounder with visual survey data from the towed camera system.

Applications of Unmanned Aerial Vehicles for Mapping Coastal Processes and Intertidal Marine Habitats

D. Ierodiaconou[1], S. Murfitt[1], B. Allan[1], A. Bellgrove[1], A. Rattray[1], D. Kennedy[2], S. Howe[3], A. Schimel[4], M. Young[1]

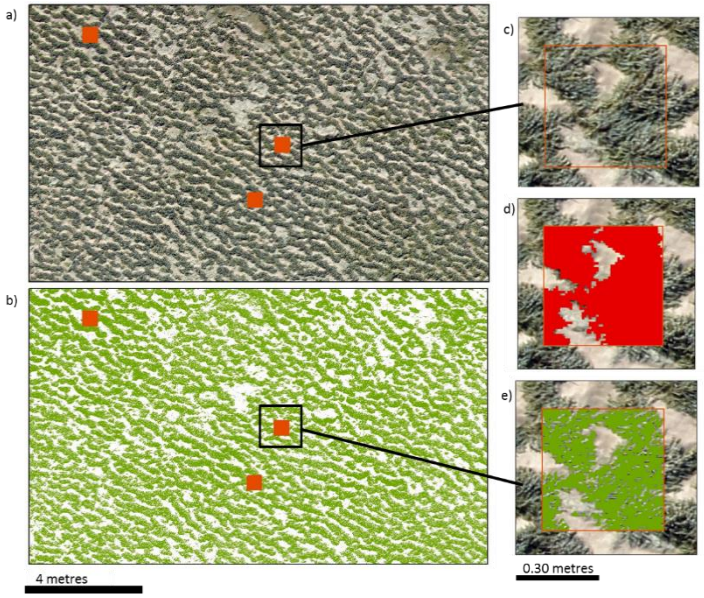
1. Centre for Integrative Ecology, Department of Life and Environmental Sciences, Deakin University, Australia
2. School of Geography, Faculty of Science, University of Melbourne, Australia
3. Parks Victoria, Australia
4. NIWA, New Zealand

To address increasingly complex research questions and global challenges (e.g. climate change and biodiversity loss), the development, refinement and need of new technology for monitoring marine coastal environments is increasing rapidly. Rapid advances in low-cost unmanned aerial vehicle (UAV) technology now allow for collection of centimetre resolution aerial imagery and topography suitable for assessing change in coastal ecosystems. We demonstrate the utility of UAV-based photogrammetry to quantify storm-driven sediment dynamics on sandy beaches and assess biotic communities on intertidal platforms by comparing on ground measurements to those that can be achieved with UAVs.

Aerial imagery collected before and after major storm events is ideal for the assessment of coastal landscape change. High-resolution aerial imagery and digital surface models were acquired and change-detection techniques used to quantify change in the beachface following a high-magnitude event. An average beach erosion of 12.24 m^3/m with a maximum of 28.05 m^3/m was observed, and the volume of sand cut from the beachface and retreat of the foredune are clearly illustrated. Following the storm event, erosion was estimated at 7,256± 504 m^3 along 550 m of beach.

We also tested the utility of UAV remote sensing of intertidal reef platforms to traditional on-ground quadrat surveys for monitoring intertidal marine protected areas (MPA), and investigated the role of UAV derived geomorphological variables in explaining observed intertidal algal and invertebrate assemblages. Sub centimetre aerial imagery and digital surface models were acquired from intertidal reef platforms, and on-ground quadrat surveys collected intertidal biotic data for comparison. UAV's provided reliable estimates of dominant canopy-forming fucoid alga such as *Hormosira banksii*, however understorey species were often obscured and underestimated. UAV derived geomorphic variables showed elevation and distance to seaward platform edge explained 19.7% and 15.9% of the variation in algal and invertebrate assemblage observed.

We demonstrate the benefits of low-cost UAVs through rapid data collection, full coverage census, and generation of UAV geomorphic derivatives for characterising intertidal biological variation and sediment dynamics in the coastal zone.



a) section of Point Lonsdale site showing 0.25 m^2 quadrats used for automated classification, b) same section shown as ISO unsupervised classification with *Hormosira banksii* represented in green, c) one of the 50 random quadrats across the site, d) manual classification of *H. banksii* for comparison with automated classification, e) ISO

Coverage and Quality of Seafloor Imagery – A Comparison Between Towed Video Platforms and AUV Borne Still Images

F. Jakobsen[1], V. Bellec[1], T. Thorsnes[1]

1. Geological Survey of Norway (NGU), Norway

The MAREANO programme has mapped c. 175,000 square kilometres of the Norwegian continental shelf and slope since 2005. Geological seafloor mapping is usually based on a combination of ship-mounted multibeam echosounders, sub-bottom profiler, grab samples and towed video platforms (Campod) for visual inspection. From a geological perspective we wanted to compare this technology with data collected from an Autonomous Underwater Vehicle (AUV) in terms of area coverage and image quality.

Here we present a pilot project where we tested the use of an AUV as a platform to collect both acoustic and visual data. An AUV borne TFish colour photo system was used to collect high quality still images of the seafloor in high spatial resolution. The average Campod video transects used in MAREANO are about 700 m long and takes c. 30 minutes. During this time interval the AUV can travel a distance between 3600– 7200 m, and cover an average area of c. 32 000 square metres. In comparison the Campod video data only covers an area of c. 1500 square metres.

The image quality from data acquired by towed video platforms and AUVs depends on a number of factors such as flight height, water turbidity, terrain roughness (particularly for AUVs), optical quality of the imaging system and wave movements (for towed systems).

We will discuss the suitability of the platforms and their pro's and con's in terms of area coverage and image quality.

Habitat Modeling as a Predictive Tool for Analyzing Spatial Shifts in Antarctic Benthic Communities due to Global Climate Change

K. Jerosch[1], F.K. Scharf[1], D. Deregibus[2], G.L. Campana[2, 3], K. Zacher[1], H.Pehlke[1], U. Falk[4], H.C. Hass[1], M.L. Quartino[2, 5], D. Abele[1]

1. Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Germany
2. Argentine Antarctic Institute, Argentina
3. Universidad Nacional de Luján, Argentina
4. Bremen University, Germany
5. Museo Argentino de Ciencias Naturales, Argentina

Ensemble habitat modeling is a tool in the multivariate analysis of arbitrary species or community distribution which combines models of best fit to an optimized model (ensemble model, EM). To simulate spatial variation of communities and predict the impact of climate change, it is essential to identify the distribution-controlling factors. Macroalgae biomass production in polar regions is determined by environmental factors such as irradiance, which are modified under climate change impact. In coastal fjords of King George Island/Isla 25 de Mayo, Antarctica, suspended particulate matter (SPM) from glacial melting causes shading of algal communities during summer. Ten different species distribution models (SDMs) were applied to predict macroalgae distribution based on their statistical relationships with environmental variables. The suitability of the SDMs was assessed by two different evaluation methods. Those SDMs based on a multitude of decision trees such as Random Forest and Classification Tree Analysis reached the highest predictive ability followed by generalized boosted models and maximum-entropy approaches. We achieved excellent results for the current status EM (true scale statistics 0.833 and relative operating characteristics 0.975). The environmental variables hard substrate and SPM were identified as the best predictors explaining more than 60 % of the modelled distribution. Additional variables distance to glacier, total organic carbon, bathymetry and slope increased the explanatory power proved by cross-validation. Presumably, the SPM load of the meltwater streams on the Potter Peninsula will continue to increase at least linearly. We therefore coupled the EM with changing SPM conditions representing enhanced or reduced melt water input. Increasing SPM by 25% decreased predicted macroalgal coverage by approximately 38%. The ensemble species distribution modelling helps to identify the important factors controlling spatial distribution and can be used to link causes to effects in (Antarctic) coastal community change.

Seabed Geodiversity of the Baltic Sea

A.M. Kaskela[1], A.T. Kotilainen[1]

1. Marine Geology, Geological Survey of Finland (GTK), Finland

Geodiversity describes the variability of the geological characteristics over a certain area. It includes e.g. geological and geomorphological features and their assemblages. Geodiversity has an intrinsic value, it provides several abiotic ecosystem services, and is associated with the biodiversity and long-term conservation of the marine environment.

We have analyzed geodiversity patterns on a glaciated epicontinental basin, the Baltic Sea. The analysis aimed to locate geodiversity hotspots and draw conclusions on contributing processes. Geodiversity was assessed in a GIS environment based on broad-scale datasets on seabed substrates, structures, and bedrock. Geodiversity was measured with three parameters: patchiness, richness and geodiversity index. Geodiversity patterns were compared with variables, which were considered to reflect geological processes under seabed conditions. The aim of the analysis was to visualize broad scale geological characteristics of the seafloor environment and to provide science-based knowledge for the ecosystem based management of the Baltic Sea. This presentation will describe the seabed geodiversity distribution of the Baltic Sea and discuss the linkages between geodiversity and various geological processes.

The analysis used seabed data provided by EMODnet program among others. The study was partly funded by the SmartSea project of the Strategic Research Council of the Academy of Finland (grant no. 292 985).

Delineation of Significant Benthic Areas in Eastern Canada using Kernel Density Analysis and Species Distribution Models

E. Kenchington[1], L. Beazley[1], C. Lirette[1], F.J. Murillo[1], J. Guijarro[1]

1. Bedford Institute of Oceanography, Fisheries and Oceans Canada, Nova Scotia, Canada

The Canadian Policy for Managing the Impact of Fishing on Sensitive Benthic Areas developed by the Department of Fisheries and Oceans Canada (DFO) in 2009 defines Significant Benthic Areas in DFO's Ecological Risk Assessment Framework as "significant areas of cold-water corals and sponge dominated communities".

Kernel density estimation (KDE) was applied to research vessel trawl survey data to create modelled biomass surfaces for corals and sponges. From these, an aerial expansion method was applied to identify significant concentrations of these taxa across eastern Canada. The borders of the areas so identified were refined using species distribution models that predict species presence-absence and/or biomass, both incorporating environmental data. We present such predictive models produced using a random forest (RF) machine-learning technique. A suite of between 54 and 78 environmental predictor variables from different data sources were used. Occurrence models performed well in general with cross-validated AUC (Area Under the Receiver Operating Characteristic Curve) values over 0.8 in most of the cases. Biomass models provided diverse results depending of the taxa and region studied. The biomass models were compared with Generalized Additive Models (GAM), which produced comparable results to random forest, although the fewer assumptions required for RF made this method more convenient.

These results have been used to identify significant concentrations of corals and sponges in eastern Canada, an essential first step in the identification of Sensitive Benthic Areas to ensure Canadian fisheries are conducted in a manner that supports marine conservation and sustainable resource use within and outside Canada's 200 nautical mile exclusive economic zone.

Habitat Mapping and Assessment in Atlantic Outer Continental Shelf Wind Energy Areas

V. Kentner[1], V. Guida[1], D. Johnson[1], J. Brink[1]

1. NOAA Fisheries, NEFSC James J Howard Marine Sciences Laboratory, New Jersey, USA

The Bureau of Ocean Energy Management (BOEM) is working with the National Oceanic and Atmospheric Administration (NOAA) Fisheries to conduct a comprehensive study of eight wind energy areas (WEAs) located along the Northwest Atlantic Outer Continental Shelf (OCS) from North Carolina to Massachusetts. The purpose of the study is to assess the current state of the WEAs and determine their suitability for the development of wind turbines.

To assess each WEA, NOAA NEFSC has compiled data from a variety new and existing data sources. The data collected includes high-resolution bathymetry from multibeam sonar (2m) and microtopography from side scan sonar (cm level), physical sediment samples from USGS and visual analysis of imagery from HabCam IV and SMAST camera pyramid, CTD scans, benthic infauna samples from sediment samples, and epifauna from trawls. The compiled data will serve as a comprehensive benthic habitat database that can be used as a baseline for evaluating impacts within the WEAs and across the entire OSC. The goal of this study is to create a comprehensive habitat assessment of each WEA including establishing relationships between physical and biological features in an effort to describe habitat distributions.

This study is utilizing several techniques to assess the habitats within the WEAs. We are applying the coastal and marine ecological classification standard (CMECS) to describe and classify the biological communities and the ecosystems within the WEAs. We are conducting various interpolations of the sediment compositions and grain size analysis to characterize the seafloor. We are also mapping multidimensional habitat features in 3D by combining benthic sediment and community data with the ranges of salinity and temperature across depth as well as across time. This assessment can be used in modeling habitat suitability for fisheries stocks and ecosystem assemblages. When combined, these techniques give insight into the environmental and community interactions in each wind energy area, providing area-specific overviews of marine habitat characteristics and vulnerability to wind energy-related development in WEAs for consideration by BOEM and offshore wind developers.

Differences in Hydroacoustic Backscatter Signals and Epifauna Growth in a Stony and Coarse Grain Habitat ("Helgolaender Steingrund", German Bight, North Sea)

L.R. Kohlmorgen[1, 2, 3], S. Coers[1, 2], K. Bischof[3], I. Kröncke[2], A. Bartholomä[2]

1. INTERCOAST Research Training Group, University of Bremen, Bremen, Germany
2. Senckenberg am Meer, Department for Marine Research, Wilhelmshaven, Germany
3. Department Biology/Chemistry, University of Bremen, Section Marine Botany, Bremen, Germany

There are a variety of methods used to observe stony and coarse grain habitats. Many of these, like video recordings by scuba divers, in situ recordings of macrofauna and photographic documentation, are expensive and complex. For geological analysis, grab samples are quite common, but represent just a small range of the actual habitat. Quantitative sampling of macrofauna is difficult. Thus is it important to develop new methods that are less expensive and can cover larger areas.

This study presents the first results of a combination of side-scan sonar data and drop camera records to study the presence and absence of macrofauna as well as the sediment grain size distribution in a stony and coarse grain habitat in the "Helgolaender Steingrund".

The "Helgolaender Steingrund" is a stony and natural coarse grain habitat of ~159 ha, 11 km east-northeast of Helgoland island in the German Bight (North Sea). It is included in the Flora-Fauna-Habitat guidelines and is part of the German Natura 2000 areas. Sampling was carried out during three different cruises from May to August 2016 with RV "SENCKENBERG".

Side-scan sonar and drop camera records show a quite heterogeneous habitat. Several areas comprising of different living communities were correlated to sediment grain size. Larger organisms, such as the European lobster (*Homarus gammarus*), the brown crab (*Cancer pagurus*) and the edible sea urchin (*Echinus esculentus*) were identified. Additionally, a cover of Bryozoan species such as *Flustra foliacea* and *Alcyonidium diaphanum* could clearly be discerned.

In conclusion, the drop camera and side-scan sonar proved to be reliable methods for the analysis of stony and coarse grain habitats such as the "Steingrund". Further analysis on the gathered data has yet to be done.

Classifying the Seafloor using a Textural Segmentation Approach

L. Koop[1], M. Snellen[1, 2], D. Simons[1]

1. Acoustics Group, Faculty of Aerospace Engineering, Delft University of Technology
2. Deltares, Utrecht, The Netherlands

Seabed habitat mapping using multi-beam echo-sounder data is a very active field of research with direct uses in protecting ecologically important areas, marine resource management, and to set legislation to safeguard the oceans.

For seafloor classification, it is important to use the best data possible but it is also important to extract the most information from the available data. Seafloor classification is often done by directly using backscatter, bathymetry, and bathymetric derivative data produced by multi-beam echo-sounder systems. A way to extract more information from the above-mentioned data is to also use texture information from the bathymetry and/or backscatter.

In this study, texture based classification was performed on bathymetry data from the Borkumse Stenen and Bruine Bank within the Dutch sector of the North Sea. The method makes use of object-based image analysis (OBIA; using eCognition). The classification results are verified by using grab samples from the DINOloket database.

The performance of texture based classification will be examined when bathymetry data alone is used as input. It will be further investigated if including texture based in conjunction with backscatter, and bathymetry based classification improves classification performance of currently existing methods. It will also be examined if rule sets developed for one area of the sea can be used to classify the seafloor in another area and the effect that differing spatial resolutions of different datasets have on the portability of texture-based classification rule sets.

Ferromanganese Concretion Bottoms as Habitats and a Renewable Resource in the Baltic Sea

A.T. Kotilainen[1], A.M. Kaskela[1], U. Alanen[1], S. Kiviluoto[2, 3], T. Kontula[3], K. Kostamo[3], L. Kurvinen[4], M. Sahla[5], A. Sippo[6], E. Virtanen[3]

1. Geological Survey of Finland (GTK), Finland
2. Centre for Economic Development, Transport and Environment, Finland
3. Finnish Environment Institute, Finland
4. Metsähallitus, Parks & Wildlife Finland, Vantaa, Finland
5. Metsähallitus, Parks & Wildlife Finland, Vaasa, Finland
6. Department of Geosciences and Geography, University of Helsinki, Finland

Ferromanganese (FeMn) concretions, also called FeMn nodules or polymetallic nodules, are iron-manganese-rich mineral precipitates on the seabed. Those concretions are found in deep waters (e.g. the Pacific Ocean) but also in shallow seas like in the Baltic Sea. FeMn concretions are formed on the seabed by natural geochemical processes, catalyzed by micro-organisms, e.g. archaea and bacteria. These supposedly renewable resources, FeMn deposits, have well known economic importance. They contain the high concentrations of iron, manganese, phosphorous but also rare earth elements and environmental pollutants. However their role e.g. in the internal loading of nutrients and their ecological significance is still relatively poorly known.

Here we present FeMn concretion data from the Finnish waters of the Baltic Sea. The data has been collected over the past decades in the national marine geological mapping program of the Geological Survey of Finland (GTK) (1984–2016) and in the Finnish Inventory Program for the Underwater Marine Environment (VELMU) (2005-2015). The data include nodule observations from nearly 300 sediment samples (e.g. box corer and van Veen grab samples), 7000 video observations/points and over 70 scuba dives.

Different types of FeMn –concretions (e.g. spheroidal, discoidal, irregular and crusts/plates) were found at the seafloor with water depths between 1–75 metres. Also the size of the concretions varied from small millimetre scale spheroidal nodules to large metre scale plates. FeMn concretions occurred in all studied sea areas, from the eastern Gulf of Finland, up north to the Bothnian Bay. However, concretion fields/sites that form a HELCOM HUB-class "Baltic bottoms with at least 90% coverage of FeMn concretions" type habitat occurred only in the Gulf of Finland and the Archipelago Sea. Sediment sample data show that FeMn concretions (1-3 cm thick layer) often cover silty clay (glacial and postglacial) seabed substrates.

FeMn concretions increase the microscale seabed heterogeneity (geodiversity) by forming relatively hard substrate on the predominantly soft seafloor sediment. Concretions provide a 3D environment and hard physical structures, and support benthic communities, probably increasing biodiversity. In addition, concretion fields and crusts can protect the seafloor from erosion by near-bottom currents. It is likely that these mineral deposits occurring in the Baltic Sea form an EU Habitats Directive habitat 'Biogenic reef', of which a representative part should be protected according to EU legislation.

Ferromanganese concretions could also provide future mineral potential. However, the sustainable utilization of these marine resources and the need for marine environment protection pose great challenges for the development of ecosystem-based maritime spatial planning processes and efficient Blue Growth.

This work is a part of the SmartSea project that is funded by the Strategic Research Council of the Academy of Finland, grant No: 292 985, and the assessment of marine habitat types (LuTU-Itämeri) that will be carried out 2016–2017 in a group of national experts from the universities, research institutes and authorities.

Mapping Macroalgae Beds and Environmental Factors for Understanding the Impact of Climate Change in the Arctic – A Case Study From Isfjorden (West Spitsbergen)

A. Kruss[1], J. Wiktor[2], A. Tatarek[2], J. Wiktor Jr.[2]

1. Institute of Marine Sciences-CNR, Venice, Italy
2. Institute of Oceanology, Polish Academy of Science, Sopot, Poland

Macroalgal beds are an important component of the coastal zone in Arctic regions. They provide habitats for a vast number of associated invertebrates and fishes and high amount of fresh organic carbon. Distribution of macroalgae is essential for estimating the overall productivity of the Arctic area and for understanding processes occurring at the sea-shore interface. Moreover, macroalgae are sensitive to environmental changes. They can be good indicators of the health and evolution of an ecosystem. Changes in environmental factors (temperature, salinity, turbidity, current velocity) may limit or influence their spatial distribution and health.

In July 2016, we carried out a multidisciplinary expedition to investigate macroalgae spatial distribution in Isfjorden and to measure significant environmental features influencing their occurrence. This survey was a first part of a 2-year monitoring project in Isfjorden and covered 3 sampling areas inside the fjord, two on the south and one on the north.
During the expedition an overall area of 4.3km² was mapped using single- and multi-beam sonars. Modern processing techniques were used to analyze water-column data signals for kelp detection and to create a map of their spatial distribution related to bottom morphology and confirmed by ground-truth data. Along with acoustic studies, we collected many underwater video recordings through all the depths in the euphotic zone. ADCP measurements in each sampling zone were carried out and 85 CTD profiles were collected.

We found considerable differences in kelp species abundance and distribution on the bottom between the northern and the southern parts of the fjord, where environmental conditions are significantly different. The southern part is influenced by salty, transparent shelf waters while the northern one is under the influence of glaciers that bring fresh water with dense sediment suspension.

We would like to present not only the results of our work but also the methodology, as efficient data collection is crucial in difficult polar conditions.

Effects of Projected Climate Change Induced Changes in Wind Patterns on the Spatial Distribution of Blue Mussels

L. Kurvinen[1], M. Sahla[2], E. Virtanen[3], M. Westerbom[1], J. Ekebom[1]

1. Metsähallitus, Parks & Wildlife Finland, Vantaa, Finland
2. Metsähallitus, Parks & Wildlife Finland, Vaasa, Finland
3. Finnish Environment Institute, Marine Research Centre, Helsinki, Finland

The projected changing climate is expected to have impacts on sea temperatures and salinities. In addition, wind patterns are projected to shift. Although projections are uncertain, noticeable changes in wind directions and patterns have already been recorded in the Baltic Sea, due to changing climate during the past decades.

Wave exposure is one of the most important environmental factor controlling blue mussel (*Mytilus trossulus*) distribution and densities. Higher exposure keeps e.g. sedimentation at a lower level, which is beneficial for the species. Sea surface wave exposure is determined by wind power and direction, additionally by below surface topography. In the northern Baltic Sea, south-western winds prevail. It is assumed that blue mussels occur at higher densities on the exposed western and south-western sides of islands, islets and reefs.

The blue mussel is a key species providing several ecosystem services, such as removal of organic nutrients by filtering water and being the main food source for many Baltic flagship species. So it is of great ecological interest to try to predict how, and where, this species will manage in the changing environment.

The blue mussel data used in this study has been collected by diving, mainly within the Finnish Inventory Program for the Underwater Marine Environment (VELMU) and samples collected 2011-2015 were included. For this study, we started by running a distribution model for blue mussel densities, using wave exposure models produced with current wind data, in combination with other relevant environmental predictors. We ran models using exposure, produced with changed wind patterns, some of which follow predictions, while some are more extreme. The aim was to see how the pattern of occurrence changes in the fragmented archipelago of southern Finland and to see if there are significant shifts in occurrences within current protected area boundaries and if currently implemented MPAs

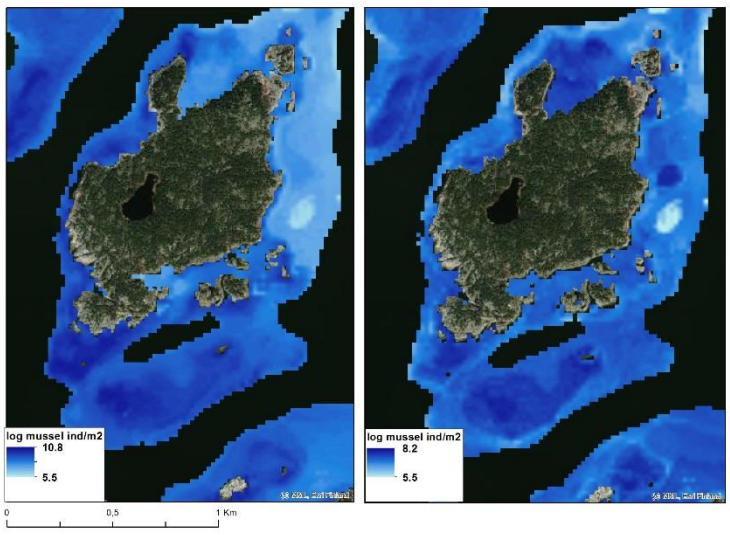


Figure 1. A current blue mussel density model (left) and a model with prevailing northern winds (right).

Results show decreasing mussel densities with shifts towards northerly winds. Also changes in locations occurred, but these shifts might not be relevant for the planning of large MPAs, if the areas include a wide range of possible exposures. On the other hand, decreasing densities might affect the way the species provides its ecosystem services.

Using the Benthoscape Approach in an Offshore Marine Protected Area – A Case Study on St. Ann's Bank (Atlantic Canada)

M. Lacharité[1], C.J. Brown[1], V. Gazzola[1]

1. Applied Research, Nova Scotia Community College, Dartmouth, Nova Scotia, Canada

The establishment of multibeam echosounders (MBES) as a mainstream tool in ocean mapping has facilitated integrative approaches towards nautical charting, benthic habitat mapping, and seafloor geotechnical surveys. The inherent bathymetric and backscatter information generated by MBES enables marine scientists to present highly accurate bathymetric data with a spatial resolution closely matching that of terrestrial mapping. A range of post-processing approaches can generate customized thematic seafloor maps to meet multiple ocean management needs, thus extracting maximum value from a single survey data set.

Applying objective segmentation methods when analyzing backscatter data collected using a variety of multibeam echo sounder systems from a study can pose challenges due to the non-calibrated nature of the sounders. The lack of backscatter calibration, due for example, to system-specific settings and characteristics of the water column during acquisition, yield relative rather than absolute values. This hinders the creation of habitat maps if multiple, non-overlapping surveys are available. Here, we first describe an approach using object-based image analysis and supervised classification to combine 4 non-overlapping and uncalibrated MBES coverages to form a seamless habitat map on St. Ann's Bank (Atlantic Canada), a proposed marine protected area hosting a diversity of benthic habitats. The benthoscape map was produced by analysing each coverage independently with supervised classification (kk-nearest neighbour) of image-objects based on a common suite of 6 benthoscape classes (determined with 4164 ground-truthing photographs at 61 stations, and characterized with backscatter, bathymetry, and bathymetric position index). Manual re-classification based on uncertainty in membership values to individual classes – especially at the boundaries between coverages – was used to build the final benthoscape map.

We then propose how this thematic map can be used to support ocean management, in particular by examining the potential role of organism-landscape relationships when framing conservation strategies. Given the costs and scarcity of MBES surveys in offshore marine ecosystems – particularly in large ecosystems in need of adequate conservation strategies, such as in Canadian waters – developing approaches to synthesize multiple datasets to meet management needs is warranted.

Linking Physical and Biogenic Habitats to Reveal Kapiti Island's Submarine Landscape

A. Laferriere[1], G. Lamarche[3], A. Pallentin[3], S. Geange[2], J. Gardner[4]

1. Blackfoot Research, Kaikoura, New Zealand
2. Department of Conservation, Wellington, New Zealand
3. National Institute of Water and Atmospheric Research, Wellington, New Zealand
4. Victoria University of Wellington, Wellington, New Zealand

Kapiti Island is one of New Zealand's most important small islands, hosting an ecologically important nature reserve that is juxtaposed by an equally important marine reserve. Although the geology surrounding Kapiti Island is dynamic with several active faults, information about seafloor morphology dates from the 1990s and has a low level of detail. Identifying the geomorphology and biogenic habitats of an area are essential to understanding the processes influencing species' distributions, ecological interactions and managing the marine environment. Through a collaborative mapping initiative, we mapped the seafloor using a Kongsberg EM2040 Multibeam Echosounder (MBES) to produce highly detailed maps of the reserve and surrounding area. Preliminary bathymetry data was visually analysed and segmented into 18 habitat types that were used to ground-truth the multibeam and define biogenic habitats. Ground-truthing included 214 camera drops, 12 sled tows and 46 dives distributed over the 18 habitat types. We present here the compilation of ground-truthing and multibeam data to reveal the diversity of physical and biogenic habitats that comprise the submarine landscape surrounding Kapiti Island, which include: soft sediments with associated infaunal communities, large areas of rock rubble and gravels with mobile invertebrates, extensive anemone and rhodolith beds, boulder fields with dense macroalgal stands, flat and complex rocky reefs encrusted with a diversity of invertebrates and algae. This multidisciplinary and scalar approach supports a greater ability to effectively manage the area and promote awareness of the richness, diversity and complexity of the seafloor of the Kapiti Island region and the biota it supports.

Management of Ecological Perspectives of Habitat Mapping at Fire Island National Seashore

M. LaFrance Bartley[1], J.W. King[1], B.A. Oakley[2], B.J. Cacciopoli[1]

1. University of Rhode Island Graduate School of Oceanography, Narragansett, RI 02882, USA
2. Eastern Connecticut State University, Dept. of Environmental Earth Science, Willimantic, CT, 06226, USA

In response to Hurricane Sandy, the National Park Service (NPS) has undertaken four submerged benthic habitat mapping projects in the Northeast Region of the U.S, including Fire Island National Seashore (FIIS) in New York. These studies represent the first comprehensive habitat mapping efforts undertaken by the NPS. The primary objective of these studies is to provide the NPS with a comprehensive baseline dataset of park submerged lands through the inventory, classification, and assessment of benthic resources and habitats developed through the integration of biological, geological, and physical data. With this enhanced, multi-disciplinary understanding of ecosystem structure and function within its parks, the NPS will promote resource stewardship and improve its capacity to initiate effective, scientifically sound management strategies. Mapping within FIIS is of particular interest because of the newly formed breachway created as a result of Hurricane Sandy, which bisects the sand barrier island separating FIIS from the ocean. The breachway has led to an influx in ocean water, consequently altering the conditions of the shallow bay environment and the associated biological communities.

The presentation will highlight several key components of the FIIS study that serve to demonstrate the value of habitat mapping from both management and ecological perspectives, including:

- The benthic habitat maps developed for study areas within FIIS. The map units were developed based on statistically significant relationships between the biological communities and the Geoform and Subform components of the Coastal and Marine Ecological Classification Standard (CMECS) – the national classification framework adopted by the Federal Geographic Data Committee;
- The effects of Hurricane Sandy on the habitats within FIIS and the surrounding area. Analyses found varying relationships between biological communities and geological and physical conditions that are believed to be based on the distance from the new breachway;
- Implications for management and the need for the establishment of a cost-effective monitoring program. While the findings from this study cannot be directly compared to pre-Hurricane Sandy conditions, there is sufficient evidence that the new breachway is having positive ecological effects. This is particularly the case within the area near the breachway, as demonstrated by the presence of mature blue mussels in dense concentrations and the emergence of seagrass beds; and
- The logistical challenges of mapping in very shallow and turbid waters. Water depths within FIIS average 1m and visibility is often less than 0.5m. Despite these conditions, full-coverage sidescan and partial-coverage bathymetry data was collected relatively rapidly using an EdgeTech 6205, which allowed as much as a 50m swath range in 2m of water. Ground-truth surveys were accomplished using grab samples and SPI imagery, since broader-coverage ground-truthing methods, such as underwater video and aerial imagery, were not possible.

Multiscale Geomorphological Classification of the Seafloor in an Active Continental Volcanic Setting – Bay of Plenty, New Zealand

G. Lamarche[1], M. Guntz[2,1], K. Mackay[1], A. Pallentin[1], A. Rowden[1]

1. National Institute of Water and Atmosphere (NIWA), New Zealand
2. École Nationale Supérieure de Techniques Avancées Bretagne (ENSTA Bretagne), France

Detailed knowledge of the physical and biological conditions of the seafloor is key to the development of economic, environmental and cultural activities in the marine environment. Full coverage information on substrate and benthic habitat relies almost exclusively on acoustic remote-sensed data provided by multibeam echosounders, subsequently ground-truthed using visual observations and physical sampling. Predictive habitat mapping provides a means to develop models of seafloor habitat in regions where only acoustic data are available.

The diverse geomorphology and benthic ecology in the Bay of Plenty makes the area a useful case study for developing regional and local models of benthic habitat: water depths range 0 - 3300 m with geomorphological features including channel, canyons, seamounts and ridges at a variety of scales. Active geology is demonstrated by the intense seismicity, dense fault network, and ubiquitous submarine volcanic activity that results in venting hydrothermal fluids at, for example, the Calypso vent fields. This environment provides habitat for benthic communities, whose structure and distribution can be expressed at a variety of scales. Multiscale seafloor topography classification is strongly dependent on the quality of the bathymetric data. In this study we combined multibeam echosounder (MBES) data from a variety of systems, data collected on transit, and dedicated scientific and hydrographic surveys, with data from the New Zealand national bathymetry model derived from historic and modern single-beam echosounder (SBES) data for areas without MBES coverage.

We integrated marine geological and oceanographic information in Benthic Terrain Models of the Bay of Plenty and the Calypso vent fields, i.e. at regional and local scales using the ESRI ArcGIS Benthic Terrain Modeler (BTM) tools, with a modified classification catalog to suit the highly variable terrain of the Bay of Plenty. Classification of the geomorphology was based on a number of morphometric parameters (e.g., slope, Bathymetric Positioning Index, curvature, rugosity) derived from the bathymetry gridded at 25 m for the region, and 5 m for the Calypso vent fields.

A 13 geomorphological class catalogue was used that differentiated large (broad slopes, basins) and local (knolls, narrow ridges/valleys) scale features. Seventy-seven percent of the 25,000 km2 study area is broad flat, the remainder is dominated by local ridges and narrow depressions. Ground-truthing data will enable us to associate biological observations to each class, and predict benthic habitat in region where no observations exist.

Scaling of Interpretation with OBIA with Backscatter Data

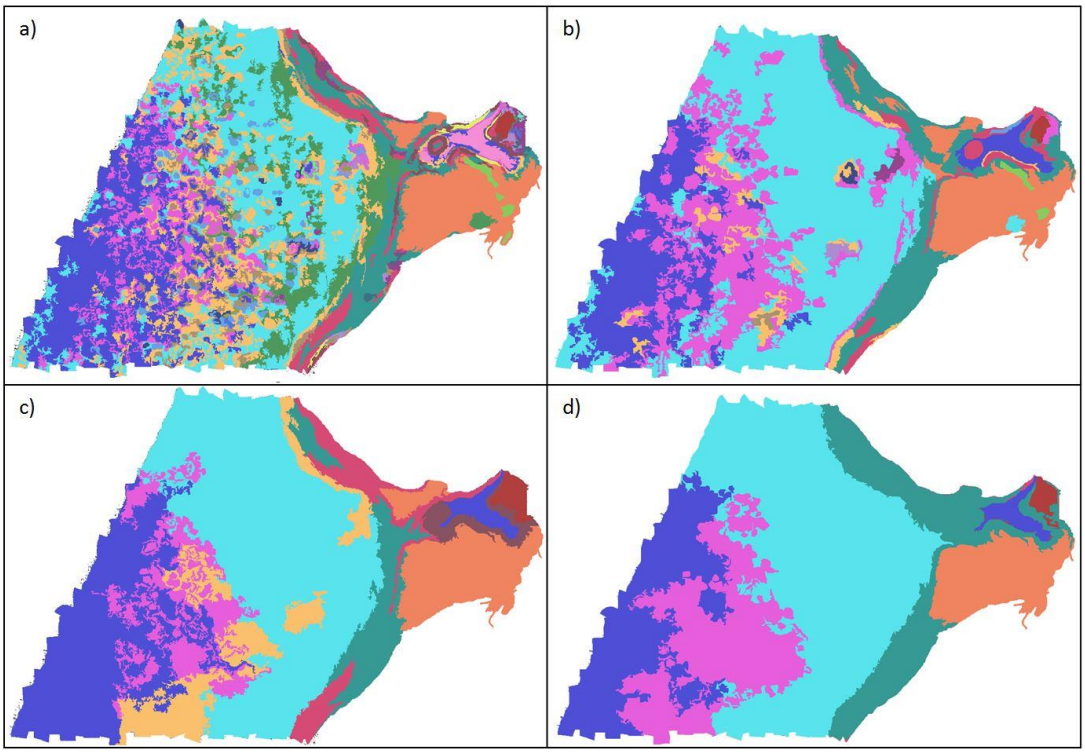
T.P. Le Bas [1]

1. National Oceanography Centre (NOC), UK

Multibeam Echosounder systems provide two datasets: a bathymetry grid and backscatter imagery. These can be combined together to produce an interpretation of these data using OBIA. The resulting interpretation divides the data into classes of similar attributes. However the question is what scale of interpretation is appropriate for the data and how does the scale of the data processing affect the results? Are the features that are extracted dependent on the processing resolution and the particular OBIA parameters?

Bathymetry and backscatter processing can be relatively automated and only have minor subjective input from the user, such as editing of outlier depths or removal of cross lines of backscatter, together with the resolution and level of smoothing.

Data will be presented at a variety of resolutions and with a variety of OBIA variables. The results will be compared to show whether the OBIA can distinguish seafloor features in the same manner as the human eye, for example to interpret either individual corals at high resolution or fields of coral at low resolution. Two sets of data will be showcased, one from shipboard multibeam over coral reefs (figure below) and one from an AUV multibeam and sidescan over rocky reef. It must be remembered however that OBIA will initially only classify areas has having similar "look" statistically, and not provide habitat identification or classification.



OBIA results for Multibeam backscatter and bathymetry data at varying resolutions.
a) High resolution data and small area OBIA, b) Lower resolution data and small area OBIA,
c) High resolution data and large area OBIA, d) Lower resolution data and large area OBIA.

Advancements in CARIS SIPS Backscatter and Seabed Classification

E. Leblanc[1], B. Foster[1], F. Viana[1]

1. Teledyne CARIS, Fredericton, New Brunswick, Canada

Following the public release of SIPS Backscatter, a new algorithm for processing multibeam backscatter imagery, Teledyne CARIS has continued investment in this approach to provide reliable backscatter mosaics that can be used to support a variety of seabed mapping tasks. A common need for seabed mapping includes seabed classification, by processing multibeam time series, beam average and multi-spectral data. Defining areas on the ocean floor with similar characteristics is a complex task involving several variables beyond pure sonar reflectivity: it is common practice to also define underwater environments using delineation parameters such as water depth and slope. With that in mind, CARIS HIPS and SIPS are currently able to provide a single high resolution raster product containing depth, slope, and intensity. In terms of seabed classification, this raster can be used as input to create acoustic classes based on the combination of layers such as depth, uncertainty, slope, aspect and intensity.

Can We Trust Our Habitat Maps? Assessing Map Sensitivity for Decision-Making

V. Lecours[1, 2], R. Devillers[2], C.J. Brown[3, 2], V.L. Lucieer[4], E.N. Edinger[2]

1. Fisheries and Aquatic Sciences, University of Florida, USA
2. Department of Geography, Memorial University of Newfoundland, Canada
3. Applied Research, Nova Scotia Community College, Canada
4. Institute for Marine and Antarctic Studies, University of Tasmania, Australia

Marine habitat maps are increasingly used to inform decisions in marine spatial planning. Despite their ability to efficiently communicate relevant information about habitats to decision-makers and stakeholders, habitat maps and species distribution models (SDMs) are only simplified representations of real habitats. While the interpretation of the outcomes and the method used to generate them should always be guided by expert advice, we still do not fully understand how the many decisions involved in map production impact the outcome. The objective of this study was to explore the sensitivity of habitat maps and SDMs to choices made when producing them.

We used a dataset of German Bank, Canada, which includes multibeam bathymetric data, backscatter data, sea scallops (*Placopecten magellanicus*) presence data, and ground-truthing video data of potential habitats. To assess the impact of spatial scale, bathymetric and backscatter data were computed at five spatial resolutions. To assess the impact of data selection, 24 terrain attributes were derived from these bathymetric data. To assess the impact of data quality, different types and levels of artefacts were artificially introduced in the bathymetric data. Different combinations of these data were then iteratively used to generate habitat maps and SDMs. First, 644 maps of potential habitats based on biophysical characteristics of the area were produced using unsupervised classifications. Secondly, 644 SDMs of sea scallops were generated using maximum entropy (MaxEnt). The performance of the maps and SDMs were quantified and compared, and the spatial distribution of potential habitats and predicted sea scallop distribution were examined.

Results indicate that variations in scale, data selection and data quality can produce very different outcomes. When selecting different terrain attributes and data of different spatial resolutions, the accuracy of habitat maps and the performance of SDMs varied, and differences up to 58% in the spatial distribution of habitats and predicted species presence were observed. Introducing artefacts also directly impacted the quality of terrain attributes at all scales, and propagated through to the habitat maps and SDMs. However, the impacts of these artefacts on habitat maps and SDMs were very unpredictable. While introducing artefacts sometimes decreased map accuracy and SDM performance, in other cases it artificially increased them. Differences in spatial distribution of potential habitats of up to 35% were observed. Local differences in habitat suitability for the SDMs reached as high as 75%, therefore changing from non-suitable to suitable area, or vice-versa. Results also show that small differences in measures of map accuracy (*e.g.* kappa coefficient of agreement) can translate into big differences in spatial distribution of habitats.

Our study showed that it is essential to remain critical of the outcomes of mapping methodologies and to recognize the limitations of the data and techniques used. Understanding the different trade-offs involved in the map production is essential when maps are to be used to inform decision-making. We recommend using multiple maps and SDMs – for instance through ensemble mapping techniques – when trying to inform spatial planning efforts. This will enable the quantification of maps and SDMs variability to different factors and account for that variability when making decisions. We should also aim to develop specific tools for assessing error and uncertainty propagation in the habitat mapping workflow. These will result in mapping products with a higher degree of confidence and lower uncertainty.

Integrating Terrestrial and Benthic Habitat Quality into Coral Reef Restoration, Conservation, and Management

P. Leingang[1], D.L. Dixson[1]

1. University of Delaware, School of Marine Science and Policy, USA

Marine protected areas (MPAs) are a major management and conservation tool used by governments around the world. The Fijian government, along with individual villages, have set up no-take MPAs within various coral reefs. Coral reefs within MPA boundaries are usually healthier, have more coral cover, and support more diverse fish assemblages than their neighbouring, non-protected reefs. The absence of fishing pressure leads to higher overall reef health; but, what other processes are occurring within the MPAs?

Recent studies have shown that some larval reef fish express a preference towards the olfactory cues of vegetation that is native to their natal reef. Unpublished data also show that larval fish exhibit olfactory avoidance of many crop-plants within Fiji (i.e. mahogany, palm oil, coconut). Rainwater runoff passes through the vegetation of a watershed and picks up the olfactory cues of the inhabiting plants before draining into the ocean. In this study, we seek to understand the influence that terrestrial developments have on coral reef health and if MPAs help to offset the negative impacts of developed watersheds.

To test this idea, we will use a DJI Phantom 4 quadcopter with a built-in near-IR camera to map the topography and vegetation species density of Tavewa Island in the Yasawa Archipelago of Fiji. Data were collected in still images taken with up to 80% overlap between images to create mosaic images with resolutions of five centimetres of the entire study area. Many individual images will be stitched together in a process known as Structure from Motion (SfM). Data sets extended from the island to the nearshore, shallow coral reefs fringing the island. The corals will be mapped for elevation, location, and species composition, which will be applied to restoration and conservation efforts. All terrestrial and aquatic images will be processed using Pix4D and maps will be generated and analyzed using ESRI ArcGIS. Topography, bathymetry, and species densities will be analyzed to determine if there exists a link between terrestrial developments and coral reef habitats.

The use of low-cost aerial remote sensing techniques provides many opportunities for enhancing coral reef health. These technological advancements have largely not been brought into this realm of study. This study will be the first of its kind directly linking anthropogenic vegetation changes to declining coral reef health. Understanding this connection will shift how coral reefs are restored, conserved, and managed.

Mapping and Monitoring Temperate Intertidal Habitats: An Object-Based Approach

P. Lightfoot[1], C. Scott[2], N. Polunin[1], C. Fitzsimmons[1]

1. Newcastle University School of Marine Science and Technology, UK
2. Natural England, UK

Intertidal habitat maps are needed at both fine and coarse scales to monitor change and inform conservation and management, but current methods of field survey and expert interpretation of aerial imagery can be time-consuming and subjective. Object-based image analysis (OBIA) of remote sensing data is an increasingly employed method for producing habitat or land cover maps. Users create automated workflows to segment imagery, creating ecologically meaningful objects which are then classified based on their spectral or geometric properties, relationships to other objects and contextual data.

Our research evaluates the potential of OBIA and remote sensing data for planning, managing and monitoring temperate intertidal Marine Protected Areas. We developed and tested OBIA workflows for interpreting ultra-high resolution imagery collected by an unmanned aerial vehicle (UAV) to map intertidal habitats at two thematic scales, comparing the accuracy, consistency and reproducibility of three supervised classification approaches. To evaluate the change-detection capability of OBIA in the intertidal environment, we developed and compared two OBIA methods for quantifying change in extent and distribution of habitats from freely available aerial and LiDAR time series data.

This talk will present and discuss our findings. We demonstrate that OBIA offers robust methods of mapping intertidal habitats from ultra-high resolution UAV imagery (mean accuracy 83.4% ± 3.8%) and lower resolution aerial and LiDAR imagery (mean accuracy 71.4% ± 1.6%) and of detecting change at different levels of sensitivity. Developed in partnership with the responsible monitoring authorities, OBIA methods could integrate ecological knowledge and remote sensing data as a basis for cost-effective intertidal monitoring protocols, providing solutions both for large-scale rapid assessment and more targeted, detailed surveys.

Marine Geodiversity of Northeastern Brazil: A Step Towards Benthic Habitat Mapping in Pernambuco Continental Shelf

D. Lucatelli[1], J.M.R. Camargo[2], C.J. Brown[3], J.F. Souza-Filho[1],
E. Guedes-Silva[1], T.C.M. Araújo[2]

1. Laboratório de Carcinologia (LabCarcino), Museu de Oceanografia Prof. Petrônio Alves Coelho (MOUFPE) Universidade Federal de Pernambuco (UFPE), Brazil
2. Laboratório de Oceanografia Geologica (LABOGEO), Departamento de Oceanografia (DOCEAN), Universidade Federal de Pernambuco (UFPE), Brazil
3. Applied Research, Nova Scotia Community College (NSCC), Nova Scotia, Canada

The Northeastern Brazil Continental Shelf (NEBCS) is one of the largest shelves off the Brazilian coast, and it is strongly influenced by volcanic and tectonic processes. It can be divided in three portions: Inner shelf (limited by 20 m isobaths), Mid-shelf (from 20 to 40 m depth), and Outer shelf (beyond 40 m depth). Pernambuco is one of the nine States from the Northeast region of Brazil, comprising a coast line of 187 Km (from 07°37.71'S to 08°54.34'S) and an average width of 33.28 Km. The littoral zone is strongly influenced by urban development, with extreme pollution in some areas, particularly near the capital Recife and the metropolitan region. Nevertheless, there are two Marine Protected Area (MPA) included in the Pernambuco EEZ, namely "Fernando de Noronha Archipelago" and "APA Costa dos Corais". However, there have been no habitat mapping studies within this region of the continental shelf, and only a small number along Brazilian coast. Based on the limited information available, the present work aimed to initiate the compilation of existing seafloor data sets on the Pernambuco region. The main objective was to map the physiography and relate it with the classes of sediment, providing a map of the geodiversity from the coast of Pernambuco (from inner to outer shelf).

To achieve the objectives of the study, abiotic data available in a public database, and results of technical-scientific surveys from the area were explored. Specifically, topography, slope, and sedimentary texture data were integrated. The topography was based on Gorini (1996). The map curvature was generated on ArcMap 10.1 software. Folks' classes were used to classify the sediment and stations were interpolated by natural neighbor. To improve the information for the locality, data from the Brazilian National Oceanographic Data Bank (BNDO) was added. Thus, a total of 314 samples were accomplished for the analyses. Multidimensional and PCA analyses were conducted using PRIMER 6.

Results of bathymetric analysis suggested some considerations: Inner and Outer shelf are narrow in the south and broaden northward along the shelf. On the other hand, the Mid-shelf is a broad southward and narrow at North portion. The slope is variable, being possible to observe several long portions with low degree (0.8-1°) of steepness along the Inner shelf. The presence of steps toward Mid-shelf could be observed as well. A flat portion is registered at the southern part of the shelf. Irregular areas are shown toward North. Pernambuco's platform presents its edge between 55-65 m, revealing an extended stability of the continental shelf, in terms of tectonic and sedimentary processes. The abrupt gradient variation of the shelf edge is clearly marked, as well as the strong steepness on superior slope. Additionally, the MDS and PCA analyses reflect the influence of terrigenous sediment, coming from continental region for the Inner shelf, and the presence of calcareous algae plus organogenic fragments (from beach-rocks and corals) on the mid and outer shelf. The sediment composition is highly relevant to the benthos distribution. Based on our results a texture map was constructed showing the general pattern for the sediment distribution along the shelf of Pernambuco.

How to Improve the Quality and the Reproducibility for Acoustic Seafloor Characterization

G. Masetti[1], B.R. Calder[1], L.A. Mayer[1]

1. Center for Coastal and Ocean Mapping/NOAA-UNH Joint Hydrographic Center, UNH, Durham, NH, USA

Current commercial solutions for processing acoustic data with the aim of seafloor characterization does not take full advantage of the wide spectra of information collected by modern sonars (e.g., water column data, multiple sectors). In addition, those solutions tend to act as a 'magic black-box' with only a few user-defined parameters. This can be seen as an advantage (it makes these technologies available to a large community), but it also engenders a lack of data reproducibility. Currently, it is a real challenge to 'properly' merge backscatter-based products from different vendors (and even from the same vendor given the lack of metadata).

In order to mitigate both issues, we developed a different approach. The proposed workflow is organized into two main phases: the first part focuses on artifact identification and reduction, while the second part is product-oriented. The artifact-oriented phase applies a (growing) set of algorithms to facilitate the identification of corrupted data so that they can then be ignored or, if required by the user, reconstructed using several different techniques. This approach also provides a metric that can then be used to identify which ping should be excluded during seafloor characterization.

The first phase is cleanly separated from the product creation. At the end of it, corrected data in the sonar's native format are generated together with an (optional) 'difference' file (containing only the data that has been modified) and a human-readable and computer-interpretable textual description of all the applied processes. This 'native-format' solution is better than converting the data to a hybrid generic data format which may not adequately preserve all of the important information from the file. The 'difference' files reduce the amount of data storage since they contain only the changes, rather than doubling the storage requirement. An additional advantage is modularity. For instance, based on the kind of survey different strategies combining the identification and reduction methods can be built. Once the valid, corrected data files are created, they can be mosaicked or analyzed for seafloor characterization by the user-preferred application.

The proposed approach is demonstrated with real-world data by first using a set of bubble washdown detection algorithms, then improving the quality of the generated outputs. Specifically, the mosaic is created after the reconstruction of the corrupted samples with a weighted randomization schema, while the seafloor characterization is improved by ignoring the corrupted data.

A possible future development of this approach is to carry all the line-based descriptions of the applied processes together with the products. To make this possible in a robust way, we propose the creation of an open, community-driven product data format mimicking what has been done for bathymetric data by the Open Navigation Surface Working Group (BAG format).

Bay-Scale Habitat Mapping of American Lobster (*Homarus americanus)*

A. McKee[1], J. Grant[1]

1. Dalhousie University, Halifax, Nova Scotia, Canada

Bay-scale habitat maps for benthic organisms, especially those of economically important species, are important for the comprehensive development of Marine Spatial Planning (MSP) initiatives. However, few such maps of that scale exist for the American lobster (*Homarus americanus*) in Canada's Maritime provinces. There are several coastal activities considered by MSP which occur at scales of less than 1 km (e.g. aquaculture, etc.), but which have limited spatial placement options because of the broadly binned or patchy lobster habitat data available.

Therefore, the objective of this project is to develop a standard method of bay-scale lobster habitat mapping specifically for the purposes of adding scientific GIS layers to the MSP process of finfish aquaculture lease placement. Two bays in Nova Scotia and New Brunswick have been surveyed and mapped using acoustic data (backscatter from a single-beam echosounding system), ground-truth video, and various forms of lobster presence data. Through different procedures, the acoustic data have been split into substrate category bins and interpolated between tracks, then compared to the ground-truth video to create error matrices and provide estimates of accuracy. The accuracy of the maps created through these differing procedures has been evaluated and the early results of this work will discussed.

Cold-Water Coral Distributions and Surficial Geology at Five Spatial Scales on the Flemish Cap, Northwest Atlantic

L.L. Miles[1], E.N. Edinger[1, 2, 3], D.J.W. Piper[4]

1. Department of Geography, Memorial University of Newfoundland, Canada
2. Department. of Biology, Memorial University of Newfoundland, Canada
3. Department of Earth Sciences, Memorial University of Newfoundland, Canada
4. Geological Survey of Canada, Nova Scotia, Canada

Cold-water coral (CWC) distributions are strongly influenced by substrate, as they are sessile, long-lived benthic species. While the attachment substrate preferences (hard vs. soft) of many coral species are well known, the relationships between coral species distributions and geological environments are less clear. This study investigates the relationship between CWC distribution and geological environments in a deep offshore setting, examining both surficial geology and bedrock lithology.

In 2010 we used a remotely operated vehicle to conduct four video surveys on the southern and eastern flanks of the Flemish Cap, NW Atlantic, ranging in depths from 870 m to 2900 m. CWC were identified to the lowest possible taxonomic level and assigned to functional groups: large gorgonians, small gorgonians, soft corals, pennatulaceans, antipatharians, *Desmophyllum dianthus*, and reclining solitary scleractinians. Surficial geology was classified at five spatial scales (10 m, 50 m, 100 m, 500 m, 1000 m) along each transect into one of six surficial geological and/or lithological geological facies (fine grained sediment, gravelly fine grained sediment, fine grained sediment and bedrock, igneous bedrock, and sedimentary bedrock).

A total of thirty CWC species were observed, with each transect displaying a unique species composition and surficial geology. Functional groups were represented on most facies and depths. *Anthomastus sp.* (soft coral) was the most abundant coral species observed, and was found on most facies and depths. Soft corals and large gorgonians were the most abundant on the gravelly fine grain and sedimentary bedrock facies between 1673–1873 m.

Analysis of Similarity (ANOSIM) showed an influence of both facies and depth on coral species composition, with depth apparently more important. Geological facies had a significant difference on coral species composition when measured at finer scales (10 m, 50 m, 100 m, and 500 m) but not at broader scales (1000m). Of the fine scales, 100 m was the most significant for both CWC species and functional groups. Our results suggest that bathymetry and oceanography are dominant influences on coral distribution at broad scales, with surficial geology dominating distributions at scales finer than 1 km.

Habitat Characterization of *Boltenia ovifera* and *Modiolus modiolus* in the Head Harbour/West Isles/Passages Ecologically and Biologically Significant Areas, New Brunswick, Canada

C.A. Mireault[1], P. Lawton[2], R. Devillers[1]

1. Department of Geography, Memorial University of Newfoundland, Canada
2. Department of Fisheries and Oceans Canada, New Brunswick, Canada

The Fundy Isles region of the Lower Bay of Fundy in New Brunswick, Canada, is a coastal area with a high benthic biodiversity. This has prompted the designation by the Department of Fisheries and Oceans Canada (DFO) of certain areas of this region as DFO Ecologically and Biologically Significant Areas (EBSA). *Boltenia ovifera* and *Modiolus modiolus* are two benthic species that have been identified as Vulnerable Marine Ecosystem (VME) indicator species that aid to the uniqueness of benthic habitats, but are vulnerable to disturbance. Those species have thus been considered a key starting point for the assessment of marine species distributions within the EBSA region.

Benthic image and video data collected at thirty stations during the summer of 2016 were analyzed for the presence and abundance of *B. ovifera* and *M. modiolus*. Target survey strata were derived using depth and slope characteristics from available multibeam data. Near-seabed drift transects were then carried out using a surface-deployed camera system. Twenty-five minute videos were analyzed in real time in lab using Transana 3.0 video analysis software. Images were extracted from the videos using FFMPEG software at 30 second intervals and analyzed using PhotoQuad 2.4. Biological data and a 1m resolution multibeam dataset of the region were used in General Additive Models (GAM) to produce predictive distribution models of *B. ovifera* and *M. modiolus*.

Preliminary results of these models show that seafloor slope and depth ($p = < 0.001$, n=809) are variables explaining the distribution of *B. ovifera*, findings that are consistent with previous studies. However, these models performed poorly in terms of the overall model output for both the image ($r^2 = 16.71\%$) and the video analysis ($r^2 = 9.56\%$). These new surveys have added significantly to our knowledge of the area- and depth-related distribution of *B. ovifera*. Finding significant aggregations of this species at depths to 75m on hard substrates suggests that prior assessments on the presence of sensitive benthic habitat in this coastal region underestimated the actual extent.

Unfortunately, there were only a limited number of observations for *M. modiolus* due to difficulties identifying them in the video and image data. This has precluded developing robust GAM models for *M. modiolus* at this time. The seabed camera was also equipped during the 2016 seabed surveys with a Nikon digital still camera that obtained higher-resolution imagery. Those additional images will be analyzed to help increase *M. modiolus* observations. Further data analysis will be conducted to refine the GAM species distribution models and test other modelling techniques, such as Maximum Entropy (MaxEnt) and Boosted Regression Tree (BRT). These models will hopefully provide insight on the impacts of the environmental factors that influence the distribution of *B. ovifera* and *M. modiolus* within the EBSA region and provide geospatial predictions of high quality habitat for consideration of conservation planning approaches.

Mind the Scale! Modeling at Multiple Scales to Predict the Distribution of Sediment Grain Size for Use in Benthic Habitat Mapping

B. Misiuk[1], V. Lecours[2]

1. Department of Geography, Memorial University of Newfoundland, Canada
2. Department of Fisheries and Aquatic Sciences, University of Florida, USA

Sediment grain size is an important habitat-defining parameter for many benthic species. Grain size distribution is affected by a number of oceanographic and sedimentological processes that operate at a variety of scales. Modeled predictions of sediment grain size can aid in benthic habitat mapping, yet the scale of processes is seldom considered in modeling, despite mounting evidence indicating the scale-dependent nature of these processes. The consideration of spatial scale can increase predictive accuracy of distribution models, and aid in understanding of the processes that drive distributions.

Sediment grain size data from 98 grab samples collected from around Qikiqtarjuaq, Nunavut, Canada were used to train distribution models of mud, sand, and gravel fractions for subsequent use in habitat mapping and sediment classifications. Sixteen predictor variables derived from multibeam echosounding data were resampled at eight different resolutions (using the *calculate terrain variable then average result over n x n window* method; Dolan, 2012), which were tested for statistical importance in predicting mud, sand, and gravel grain size fraction distributions. Optimal resolutions were determined for each predictor variable, which were subsequently used to train compositional distribution models of mud, sand, and gravel grain size fractions in a Boosted Regression Tree model, using a methodology similar to that of Diesing (2015). Results demonstrated that the default multibeam data resolution (5 m) was often not the optimal choice for predictor variables, with coarser resolutions often explaining more statistical deviance. This reinforces the importance of considering or testing multiple spatial scales in distribution modeling. Identifying variable-specific scales aided in understanding the drivers of sediment grain size distribution in the area around Qikiqtarjuaq, and resulted in a high 10-fold cross-validated predictive accuracy (Spearman correlations of ρ_{mud}=.772, ρ_{sand}=.712, ρ_{gravel}=.578). Predictions of mud, sand, and gravel grain size fractions were subsequently combined into a Folk (1954) grain size classification, and were used in species distribution models to support conservation and management of marine resource development around Qikiqtarjuaq, Nunavut, Canada.

In-Situ Appraisal of Near-Bed and Water-Column Particle Transport on MBES Backscatter

G. Montereale-Gavazzi[1, 2], J. De Bisschop[1, 2], M. Roche[3], K. Degrendele[3], M. Baeye[1], F. Francken[1], V. Van Lancker[1, 2]

1. Royal Belgian Institute of Natural Sciences, Operational Directorate Natural Environment, Brussels, Belgium
2. Ghent University, Department of Geology, Renard Centre of Marine Geology, Gent, Belgium
3. FPS Economie, Service Continental Shelf, North Gate, Brussels, Belgium

Within the European legislation and the Marine Strategy Framework Directive, the substrate composition is the backbone of many environmental indicators. To assess its type and extent, seabed mapping by multibeam echosounding (MBES) is increasingly used. Nonetheless, to monitor the environmental status of the seafloor, evaluations are needed on the precision, sensitivities and repeatability of the acoustic observations; taking into account the factors other than those exclusively related to the seabed that may influence the MBES backscatter (BS) level from one survey to another. This is especially the case for MBES BS since its decibel values' ranges, being a proxy of seabed type, depend on a range of instrumental and environmental parameters that need quantification before individual data products can be compared from one survey to another, even at small spatio-temporal scales. Results relate to assessing the effect of tide-related phenomena, including suspended particulate matter concentration (SPMC) and near-bed sediment load on MBES BS of the seabed. During a 13h tidal cycle MBES BS was collected in combination with oceanographic data using a benthic lander equipped with sensors such as current and turbidity meters a particle-sizer and sediment traps. Overall, a difference of over 3 dB (across all incidence angles 0–75°) and around 2dB (for the oblique incidence angles 30–50°) was found over the tidal cycle which is significantly higher than the acceptable 1 dB variability given by the manufacturer. Most striking was the more reflective character of MBES BS during slack tide and near the peak currents at high flood water, whilst the signal was more absorbed during peak ebb phase. Slack conditions may be associated with flocculation, leading to increased reflectivity, whilst the MBES BS reflective character at peak flood currents may be due to higher SPMC. On the other hand, increased absorption during the ebb phase is related to the increased SPMC concentrations in the near-bed. Whilst the deciphering of the driving hydro-meteorological forces is still on-going, it is clear that the observed variation in decibel range needs accounting for when evaluating changes in MBES BS in a monitoring context (e.g., MSFD related). This will be most critical in areas with high sediment dynamics. Ideally, synchronous measurements of MBES BS and water column properties are conducted and appropriate correcting factors established.

Mapping of Ecological Functions on the Flemish Cap (Northwest Atlantic)

F.J. Murillo[1], E. Kenchington[1], M. Bouchard Marmen[1], M. Koen-Alonso[2], M. Sacau[3], P. Duran Muñoz[3]

1. Bedford Institute of Oceanography, Fisheries and Oceans Canada, Nova Scotia, Canada
2. Northwest Atlantic Fisheries Centre, Fisheries and Oceans Canada, Newfoundland, Canada
3. Instituto Español de Oceanografía, Centro Oceanográfico de Vigo, Programa de Pesquerías Lejanas, Vigo, Spain

Ecosystem Approaches to Fisheries (EAF) are seen as essential for sustaining fish stocks and fisheries over the long-term, and require the integration of ecosystem components, typically through multivariate and multifunction analyses. Large scale functional maps showing the distribution of organisms with particular biological traits (e.g., deposit feeders, filter feeders, biogenic engineers, carbon sequesters, etc.) can provide a detailed spatial framework for incorporating benthic ecosystem function into an ecosystem services framework.

Building on this experience, here we propose that combining biological traits analyses (BTA) with seabed mapping can be used to identify areas according to dominant ecological function, which can provide a detailed spatial framework for considering ecosystem services within the overall EAF. Furthermore, identification of the environmental determinants for each function could allow evaluating responses of the function to fishing and future climate change.

Based on the epibenthic invertebrate fauna from a bottom trawl research survey targeting groundfish in the Flemish Cap area (northwest Atlantic), functional maps with particular biological traits have been elaborated. The different ecological functions or ecosystem services represented on these maps can be used, for example, to identify areas where biogenic process could represent an important regulator and driver of overall benthic productivity versus areas where physical factors may be more relevant for driving overall benthic production or they can help to identify areas where ecosystem changes may have happened. These types of maps can be incorporated into the Northwest Atlantic Fisheries Organization (NAFO) Roadmap as part of the assessment of ecosystem sustainability to achieve an EAF.

4D at its Highest:
Interactive and Reliable Acoustic and Optic Imagery Workflow

D. Neville[1], D. Febres Urdaneta[2], C. Malzone[3]

1. Fledermaus Product Manager, QPS Canada
2. Fledermaus Support Product Manager, QPS Canada
3. General Manager, QPS-US Inc.

The evolution of technology allows the collection of ever higher resolution data, which is needed to fully understand our underwater environment. These increased resolutions, and corresponding data sizes, make the combination of technologies and data types more and more difficult. Attempting to work in different software packages with these large datasets can be costly and time consuming, and might include ad hoc methods, that will make results of the process unreliable and not as accurate as the technology evolution promised. For example, for any habitat analysis to be successful and reliable; it needs to follow a rigorous methodology that would support subsequent studies and is easily repeatable.

The use of video and imagery-based data, from camera drops or an ROV/AUV, is becoming a sound source for added value to acoustic surveys, and key for a ground thruthing process. We will present a proof of concept workflow for online or post acquisition analysis of video data in combination with high-resolution multi-beam, both bathymetry and backscatter, as well as auxiliary data types. This workflow will be illustrated for different example scenarios, such as quantitative habitat analysis, infrastructure/anthropological structure analysis, and fisheries examples for habitat mapping. Through the application of the interactive 4D visualization and intuitive analysis tools within Fledermaus, we provide a robust and efficient bridge between high volumes of video data, high-resolution bathymetry and backscatter data, and diverse auxiliary data, to enable high precision interpretation and eventing.

The opportunity to work with these data types, merged and time synced, allows further advanced analysis even to quantitative samples, albeit with further increases in data volumes. Our solution overcomes the data volume challenges and maximizes the benefits of using a single stop software package that readily enables the creation of a spatial database model to be exploited for statistical and quantitative analysis. Combining multiple time-sensitive 3D objects into a scene allows discovery and analysis within that environment. This additionally provides insight for any future planning by integrating both the raw survey data and the interpretation of the data at difference user levels.

Development of a New Acoustic Mapping Method for Eelgrass Using a Multi-beam Echo-sounder

A.R. Norton[1], S.J. Dijkstra[1]

1. Center for Coastal and Ocean Mapping, University of New Hampshire, USA

Eelgrass plays important roles in temperate coastal ecosystems, including as primary producers and as habitat for many species. The distribution and health of eelgrass beds are also sometimes used as a bio-indicator for water quality. The deepest edges of eelgrass beds are especially vulnerable to water quality issues because of the pre-existing light limitation with increasing depth due to natural light attenuation. However, the deep edges of beds are also often the most difficult to delineate with satellite and aerial imagery often used for large-scale seagrass mapping programs; the use of aerial imagery for mapping eelgrass beds is also sometimes hindered by turbidity issues common in estuarine environments. We are in particular developing methods to determine and map the maximum depth limit ('deep edge'), percent cover, functional type (i.e., macroalgae or eelgrass) and canopy height of the beds using water column backscatter data from a multi-beam echo-sounder because these characteristics are difficult to obtain using existing optical and acoustic methods. Water column data was collected using an Odom MB1 sonar in 2014 and 2015 over a variety of vegetated sites in New Hampshire and Massachusetts, selected to represent a range of conditions: dense/sparse eelgrass, long/short eelgrass, mixed macroalgae and eelgrass, eelgrass on muddy or hard substrates, etc. The data processing workflow will look at both echo and terrain characteristics to determine the presence and characteristics of vegetation. In addition to sonar data, drop camera data was collected, and data from a regional aerial mapping program also exist for comparison. Initial data analysis shows good agreement between drop camera and sonar detections, and patches as small as $1m^2$ and as short as 20 cm are detectable.

From Single-Species to Biodiversity Conservation? Habitat Mapping and Biodiversity Analysis of the Eastport Marine Protected Area, Canada

E. Novaczek[1], B. Proudfoot[1], V. Howse[2], C. Pretty[1], R. Devillers[1], E. Edinger[1, 3], A. Copeland[4]

1. Department of Geography, Memorial University, Canada
2. Centre for Fisheries and Ecosystem Research, Marine Institute, Memorial University, Canada.
3. Department of Biology, Memorial University, Canada
4. Department of Environment and Natural Resources, Government of Bermuda, Bermuda

As a signatory to the Convention on Biological Diversity, Canada has committed to protect at least 10% of its coastal and marine waters by 2020 through ecologically representative and well-connected systems of protected areas. As more nations implement additional marine conservation measures to meet international targets, understanding how existing protected areas contribute to broader conservation goals is important. Our study describes the benthic habitat mapping of a small Canadian MPA and reports on its contribution to conservation of regional benthic marine biodiversity. We also suggest methods for incorporating benthic habitat connectivity analysis into adaptive management processes.

The Eastport MPA (Newfoundland, Canada) is a 2.1 square kilometre no-take reserve designated in 2005, based on a voluntary fishery closure implemented in 1997. The primary goal of the Eastport MPA is to protect and sustain the American lobster (*Homarus americanus*) population, which supports an important local fishery. The MPA's stated management goals also include protection of benthic biodiversity and protection of rare and endangered species. Benthic habitats within and adjacent to the MPA were characterized and mapped using multibeam echosounder data and seafloor videos. Three statistically distinct benthic habitats were identified within the boundaries of the MPA: 'shallow rocky', 'sand and cobble', and 'sand'. The distribution of species was primarily driven by depth and substrate type. The shallow rocky habitat (48% of the study area) contains complex bedrock and boulder features with high macroalgal cover, which are associated with juvenile and adult American lobster habitat. However, a previous study covering a broader area identified 10 distinct habitats in Newman Sound, the area surrounding the MPA. Species composition was also significantly different inside and outside the MPA, with much lower species richness within the protected boundaries. These results indicate that this small MPA contributes little to the conservation of the regional marine biodiversity, vulnerable habitats, or species at risk.

The high resolution marine habitat maps produced provide the opportunity to apply landscape ecology concepts, such as habitat connectivity metrics, to support marine conservation and adaptive management initiatives. In Eastport, benthic habitat connectivity is currently being assessed to identify areas that could be selected for a possible MPA expansion. Preliminary results derived from applying Patch Cohesion and Connectance Indices suggest that while habitats within the MPA are highly contiguous, connectivity between corresponding habitat patches is low. Further analysis of benthic habitats outside the MPA may help to identify possible solutions that maintain continuity and enhance connectivity with new or expanded protected areas. The results of this study will support adaptive management, something rarely done for Canadian MPAs, and will contribute to the development of methods for the identification of effective and well-connected MPA networks.

An Indirect Approach to Classify Backscatter Data for Soft Bottom Habitat Mapping

A. Pazzini[1], R. Proietti[1], S. Agnesi[1], A. Annunziatellis[1], L. Nicoletti[1]

1. Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), Italy

The availability of wide area habitat maps is a key aspect for several marine assessment scenarios. The development of innovative, quick and low cost methods to produce such maps is therefore crucial to overcome the actual knowledge gap. Multibeam echosounder (MBES) backscatter data acquisition is largely used to collect geophysical data which are then post processed versus *in situ* data (sediment and/or biological samples) to classify the acoustic response (hereafter direct method). However, many parameters as roughness, porosity, presence of gas seeps, etc. strongly affect the results. In fact, a number of recent works highlight that the availability of backscatter and sediment data is not sufficient to evaluate the relationship between acoustic response and seabed substratum (De Falco et al., 2010; Ferrini and Flood, 2006; Goff et al., 2000; Sutherland et al., 2007). This is particularly true in big areas, which are often characterized by wide depth range and heterogeneous substrata and where *in situ* data can be insufficient. In order to exceed these critical aspects in backscatter data elaboration, a new procedure (indirect method) is presented in this work. The proposed classification method can be synthetized as follows: (1) MBES backscatter data cleaning and homogenization, (2) identification of "disturbed" areas (i.e. trawled areas, dredging areas, etc.), (3) MBES backscatter data clustering with identification of a high number of acoustic facies (a multiple of the sediment classes recorded by in situ samples), (4) association of different acoustic facies to a specific sampled sediment class.

This procedure was tested in a study area located in the North Latium coast in the central Tyrrhenian Sea. This area extends 30 square kilometres with a depth range between 40 and 100 metres, mainly characterized by soft bottom.

The application of the proposed method classifies six groups of acoustic facies allowing adequate control of the difference in backscatter response (i.e. due to attenuation with depth). Furthermore, this method provides encouraging results also in areas with a very low number of *in situ* samples.

The comparison between direct and indirect methods confirms the usefulness of this approach for the identification of soft bottom habitats in wide areas.

The Influence of the Scale of Enquiry and Estimated Biological Parameters On the Biological Signal Obtained from Underwater Video Data

T.R.R. Pearman[1], A. Bates[1], K. Robert[2], A. Callaway[3], C. Lo Iacono[2], R. Hall[4], V.A.I. Huvenne[2]

1. Ocean and Earth Science, University of Southampton, Southampton, UK
2. National Oceanography Centre (NOC), Southampton, UK
3. Centre for Environment, Fisheries and Aquaculture Science (Cefas), Lowestoft, UK
4. School of Environmental Sciences, University of East Anglia, Norwich, UK

Accurate spatial representation of communities and species diversity is integral to elucidating factors that drive spatial structure and habitat distributions. Spatial structure results from the complex interplay of species responses to environmental drivers and spatial autocorrelation generated by community dynamics. These processes act over multiple scales. However, the scales at which datasets are obtained for benthic studies are often constrained by technological capabilities, rather than reflecting scales at which phenomena are suspected to operate.

Studies of benthic assemblages have demonstrated that the biological parameters chosen and scale of enquiry can influence the patterns obtained. Submarine canyons are heterogeneous environments characterised by high species turn over, where few species are shared between patches. Consequently, canyon settings could be more susceptible to these methodological biases.

This study utilised ROV video data from the Whittard Canyon, collected during the JC125 expedition funded by the ERC CODEMAP project (Starting Grant no 258482) and the NERC MAREMAP programme. Video analysis was conducted to identify, enumerate and georeference mega benthos utilising OFOP 3.3.7a software. Transect data was subdivided into segments of different lengths within which species records were consolidated and diversity parameters estimated. The subsequent patterns in diversity produced by different segmentation lengths and diversity parameters were compared to assess 1) if the scale of enquiry and biological parameters estimated affect the spatial patterns of diversity obtained from ROV video data and 2) which parameters are most appropriate for representing the biological structure within heterogeneous canyon settings.

The results from this study will feed into conceptual models for subsequent predictive habitat modelling within the canyon.

Evaluating Nearshore Mapping Capabilities of an Autonomous Kayak

T. Pilegard[1], S. Dohner[1], A. Trembanis[1]

1. University of Delaware, USA

Deep drafted survey vessels, autonomous underwater vehicles, and expensive aerial LiDAR surveys have limitations when conducting bathymetric surveys in the nearshore, shallow, turbid conditions. These limitations are overcome with lightweight, shallow drafted autonomous surface vehicles (ASVs).

Here, an autonomous kayak is tested as a practical, nearshore bathymetric survey platform, particularly in response to storm events. The accuracy and functionality of the autopilot aboard the kayak was evaluated, and the preliminary results show the on-track variability to be within 10% of the error of the autopilot's GPS. The autonomy of the system allows for repeatable and comparable data sets over the same area.

A storm in January 2017 allowed for a storm response survey in which the kayak was deployed three days before and six days after a storm event occurred at Broadkill Beach, Sussex County, DE. These surveys further proved the viability of such a platform for not only nearshore coastal surveys but storm response bathymetric surveys as well.

The quality of bathymetric and side-scan data recorded by two different single beam echo sounder/side-scan units have also been compared and evaluated, allowing for a cost-benefit analysis of the platform's payload. The preliminary budget for the kayak platform, including a single beam echo sounder/side-scan unit is relatively inexpensive at $3000. Based upon the early results of accuracy, cost, and modularity of this system, it is a viable platform for nearshore bathymetric surveying.

How to Homogeneously Map Adjacent Backscatter Datasets at Regional Scale – A Case Study from the Southern Adriatic Sea (Italy)

M. Prampolini[1], F. Foglini[1], L. Angeletti[1], E. Campiani[1], V. Grande[1], A. Mercorella[1]

1. National Research Council, Institute for Marine Sciences, Bologna, Italy

Benthic habitat mapping is a field of marine research highly developed in a small time-span. Classification of backscatter data constitutes a key approach, and one of the most widespread approaches, for seabed and benthic habitat mapping and a large number of methodologies are described in literature. The first method used is the visual interpretation of backscatter imagery, but it is subjective and time-consuming. Then, taking inspiration from the terrestrial remote sensing, automatic classifications have been developed based both on signal (e.g. ARA) and/or image analysis (e.g. TexAn, Principal Component Analysis, Neural Network). Image analysis is the most applied approach, both for supervised and unsupervised classification because it describes large-scale organizations of seafloor substrate and benthic habitats better than backscatter signal analysis. However, any type of image segmentation based on pixels as units of analysis may lead to some disadvantages such as noisy results, uni-scale approach, texture considerations, context and shape and, finally, pixels are not true geographical objects. For this reason Object-Based Image Analysis (OBIA) is getting more and more success since it is devoted to segment the backscatter image in "meaningful image objects" and should be able to overcome the differences among backscatter datasets acquired with different instruments.

In the last ten years, a large amount of high resolution bathymetry, backscatter data and seafloor samples have been acquired in the Southern Adriatic Sea (Italy), a physiographically complex basin hosting a variety of benthic habitats. The latter constitutes an ideal laboratory for integrated methodologies aiming at habitat mapping at different scales, in different seafloor settings and including heterogeneous datasets. The most challenging aspect of benthic habitat mapping is given by the necessity to produce an integrated map that could unify different datasets, showing comparable results. Within this framework, we present the classification of the backscatter data of some key areas of the Adriatic seafloor: we chose to apply the OBIA classification since it could be the most suitable approach in order to overcome the differences in backscatter intensity and imagery due the use of different devices.

The Use of 3D Photogrammetry to Investigate Cold-Water Coral Habitat Structure and the Spatial Distribution of Associated Communities

D.M. Price[1], K. Robert[1], V.A.I. Huvenne[1], A. Bates[1], C. Lo Lacono[1], R. Hall[2], A. Callaway[3]

1. National Oceanography Centre, UK
2. University of East Anglia, UK
3. Centre for Environment, Fisheries and Aquaculture Science (CEFAS), UK

Seafloor mapping at different scales via multibeam echosounder (MBES) has become a prominent tool for characterizing marine habitats. Cold-water coral reefs, for example, have been mapped from shipboard, AUV and ROV mounted MBES systems, providing increasing clarity into their spatial extent and habitat heterogeneity. Structure from Motion (SfM) techniques which create high-resolution 3D models of habitats are being increasingly utilised, in tandem with the potential for 3D spatial analysis in ecological research. This tool is becoming especially common for surveying shallow water coral reefs. Here we provide 3D reconstructions of a cold-water coral reef, located at 750m water depth in the Explorer Canyon, a tributary of the Whittard Canyon, NE Atlantic – England's only known living coral reef.

ROV video data were collected during the JC125 expedition, funded by the ERC CODEMAP project (Starting Grant no 258482) and the NERC MAREMAP programme. These data were processed with Agisoft Photoscan software to reconstruct 3D point-cloud models for an area covering 11.3mx8.7m of the reef. Digital elevation models derived from the 3D reconstruction allowed for spatial terrain analysis. Rugosity and slope clearly relates to reef patches as expected, showcasing the habitat complexity that coral adds to the environment, and rugosity values were comparable to tropical coral reefs. Viewing the reef from different angles revealed the presence of individual organisms that would have otherwise been missed by a typical linear transect. Using the raw video data and 3D model, we were able to plot the fine scale distribution of reef inhabitants. The use of habitat suitability modelling with the 3D reconstructions provided promising insights into what drives fine-scale species distribution and biodiversity within reef habitats. Ultimately, analysing fine-scale parameters of cold-water coral reefs in 3D provides novel and detailed information about reef communities.

Full-Coverage Seafloor Mapping in the German Exclusive Economic Zone: Interim Results on Coverage and Geodata

C. Propp[1], A. Bartholomä[2], C. Hass[3], P. Holler[2], S. Papenmeier[3], P. Richter[4], K. Schwarzer[4], F. Tauber[5], M. Zeiler[1]

1. Federal Maritime and Hydrographic Agency, Germany
2. Marine Research Department, Senckenberg am Meer, Germany
3. Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Wadden Sea Station Sylt, Germany
4. Kiel University, Institute of Geosciences, Sedimentology, Coastal and Continental Shelf Research, Germany
5. Leibniz Institute for Baltic Sea Research Warnemünde, Germany

Offshore activities and marine environment protection promote the substantial need of habitat maps that sufficiently characterize and represent the abiotic and biotic conditions on the sea floor. Therefore, detailed information of seabed sediment types is essential for a wide range of applications. According to the implementation of EU directives, high-resolution sediment data are a prerequisite for the identification, monitoring and protection of marine benthic biotopes in European marine waters.

Midyear 2012, the Federal Maritime and Hydrographic Agency (BSH) of Germany has started a sediment mapping program in cooperation with the Federal Agency for Nature Conservation (BfN) based on side-scan sonar and ground truthing using grab sampler and underwater video. To establish a standardized mapping procedure, BSH and its R&D partners AWI, CAU, IOW and SaM have developed a technical guideline on the requirements for the collection, processing and interpretation of side-scan sonar backscatter data. For the latter, standardized strategies were defined for the classification and discrimination of different seafloor sediment types in order to minimize the subjectivity of expert interpretation. *

Different levels of classification have been introduced for the sediment types, primarily based on the FOLK scheme. In addition, sand is classified according to the national classification scheme (Figge classification) to meet the requirements for biotope modelling on the sandy shelf of the German North Sea sector. Datasets of sediment distribution include additional information about the genesis of sediment types as well as the type of transition between them.
Data collection and processing could be finalized for large areas, older data has been processed and the interpretation of backscatter mosaics according to the guideline is ongoing steadily. Here, the actual status of these works is shown and latest difficulties are discussed.

*Download mapping guideline:
http://www.bsh.de/en/Products/Books/Guideline_for_Seafloor_Mapping2016/index.jsp

Correlating High-Resolution Multibeam Sonar Backscatter with Benthic Sediment Grain-Size Distributions to Aid Numerical Modeling in the Mississippi Bight

L. Quas[1], I. Church[2], S.J. O'Brien[1], J.D. Wiggert[1]

1. Division of Marine Science, University of Southern Mississippi, Stennis Space Center, Mississippi, USA
2. Geodesy and Geomatics Engineering, University of New Brunswick, New Brunswick, Canada

Multibeam acoustic backscatter intensity data can serve as a proxy for the composition and distribution of surficial seabed sediments, but without calibration and realistic seabed models there can be uncertainty in the analysis. Mosaics of the acoustic response of the seabed normalized to a fixed grazing angle provide an indication of spatial variations in seabed scattering and, therefore, an estimate of general grain-size distributions. These characteristics, along with multibeam bathymetry and sediment ground truth, can be used to inform numerical model development, like the high resolution biogeochemical/lower trophic level synthesis model being developed as part of the Gulf of Mexico Research Initiative's (GoMRI) CONsortium for oil spill exposure pathways in COastal River-Dominated Ecosystems (CONCORDE) project.

One of the necessary model inputs is bottom sediment characterization that influences local sediment transport and resuspension. To obtain this input parameter, a Teledyne Reson SeaBat 7125 SV2 multibeam sonar was operated to collect seafloor acoustic backscatter data. Surficial sediment cores and grain-size analyses were performed at select locations along the CONCORDE observational corridors to constrain the backscatter data, produce acoustically-derived sediment distribution maps, and provide sediment type input parameters for the biogeochemical model. The numerical model simulations are used to assess sediment transport in the river-dominated, coastal environment of the Mississippi Bight region on hourly to daily timescales. The sediment distribution corridor maps developed as part of this project will further our understanding of the benthic and demersal ecosystems within the Mississippi Bight.

Distinguishing Between Two Canopy-Forming Kelp Species (*Macrocystis* sp. and *Nereocystis* sp.) on the Central Coast of British Columbia Using Object-Based Image Analysis with WorldView-2 Pansharpened Imagery

L.Y. Reshitnyk[1], E.M. Rubidge[2]

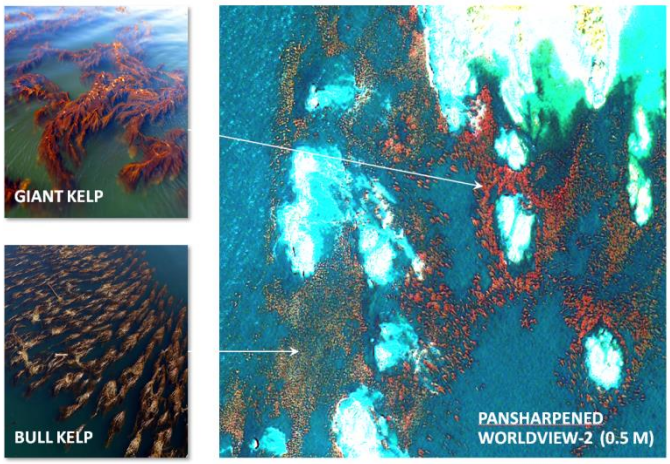
1. Hakai Institute, Heriot Bay, British Columbia, Canada
2. Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, British Columbia, Canada

Canopy-forming kelp, which include giant kelp (*Macrocystis integrifolia*) and bull kelp (*Nereocystis luetkeana*) have been identified as ecologically significant species on the coast of British Columbia (BC). Giant kelp and bull kelp provide crucial habitat for multiple fish and invertebrate species, and they play a key role in nearshore nutrient and flow regimes. The spatial distribution of both kelp species is a crucial and currently missing input for marine protected area network planning and long-term ecological research.

An ongoing collaboration between the Hakai Institute, based on the Central Coast of BC, and the Pacific Region of Fisheries and Oceans Canada, seeks to examine the application of satellite imagery for mapping kelp extent on the BC coast. A primary objective of this research is to determine whether object-based image analysis (OBIA) could be used to differentiate and delineate the extent of both giant and bull kelp using high resolution satellite imagery.

A subset of pansharpened WorldView-2 imagery (0.5 m resolution) was selected for a region (McMullin Island group) on the Central Coast of BC where both species are known to be present. Knowledge of the region is extended via available field data and local ecological knowledge. While bull kelp and giant kelp have very similar spectral signatures (both are brown algae), they have very different morphologies. These morphological differences indicate that texture analysis would be best for species differentiation. Using recursive feature elimination, image feature variables (both spectral and textural) showed high differentiation between species. These variables were used as inputs for OBIA using eCognition software to test four scales of image segmentation and three different image classifiers.

The results of our study demonstrate high classification accuracy for mapping bull and giant kelp. We obtained user's and producer's accuracies greater than 90% for both kelp species using a random forest classifier. We also observed an effect of the scale of image segmentation on the results of the classifications. Overall, these methods and results demonstrate a first and novel instance of the application of OBIA for mapping multiple co-occurring species of canopy-forming kelp. Future research will include examining the effects of tide height and geographical location as well as developing methods for modelling kelp biomass.



Mapping of Complex Structures: High Resolution 3D Renditions of Vertical Coral Reefs

K. Robert[1], V.A.I. Huvenne[1], D.O.B. Jones[1], L. Marsh[2], A. Georgiopoulou[3]

1. National Oceanography Centre, Southampton, UK
2. University of Southampton, Southampton, UK
3. University College Dublin, Ireland

Vertical and overhanging walls in complex deep-sea environments can harbour high biodiversity and host vulnerable marine ecosystems, to which they provide natural protection from certain human activities (e.g. trawling) as a result of their geometry. As such, it is important to understand their ecology, but traditional ship-board multibeam echosounders cannot adequately replicate the complete 3D structure of vertical habitats, and towed video systems are challenging to operate in these rugged environments. In this study, we employed novel photogrammetry techniques (structure from motion, SfM) to create 3D representations of ROV video transects along vertical walls on the Rockall Bank Slide Complex and the Whittard Canyon, Northeast Atlantic. SfM allows such reconstructions to be created using a single camera moving around a scene, dispensing from more complex stereo-pair acquisition systems and allowing previously collected footage to be re-examined. With these reconstructions, it was possible to interact in 3D with extensive sections of video footage which cannot otherwise be visualized in their entire context. Once georeferenced, these models allowed for positioning of individual organisms at very fine scales and terrain variables could be derived on scales similar to those experienced by megabenthic individuals (<1cm for photogrammetry). The finer resolutions now achievable through these advances allowed differences in terrain conditions selected by different morphospecies of cold-water corals to be quantified. In addition, since the SfM reconstructions retained colours, they were employed to separate and quantify in 3D (e.g. surface area, volume) live coral colonies versus dead framework. These new technologies allow us, for the first time, to map the physical 3D structure of previously inaccessible habitats at very high resolutions and demonstrate the complexity and importance of vertical walls.

This work is part of the ERC CODEMAP project (Starting Grant no 258482) and data were collected during the CODEMAP2015 cruise and the SORBEH expedition (Marine Institute, Ireland).

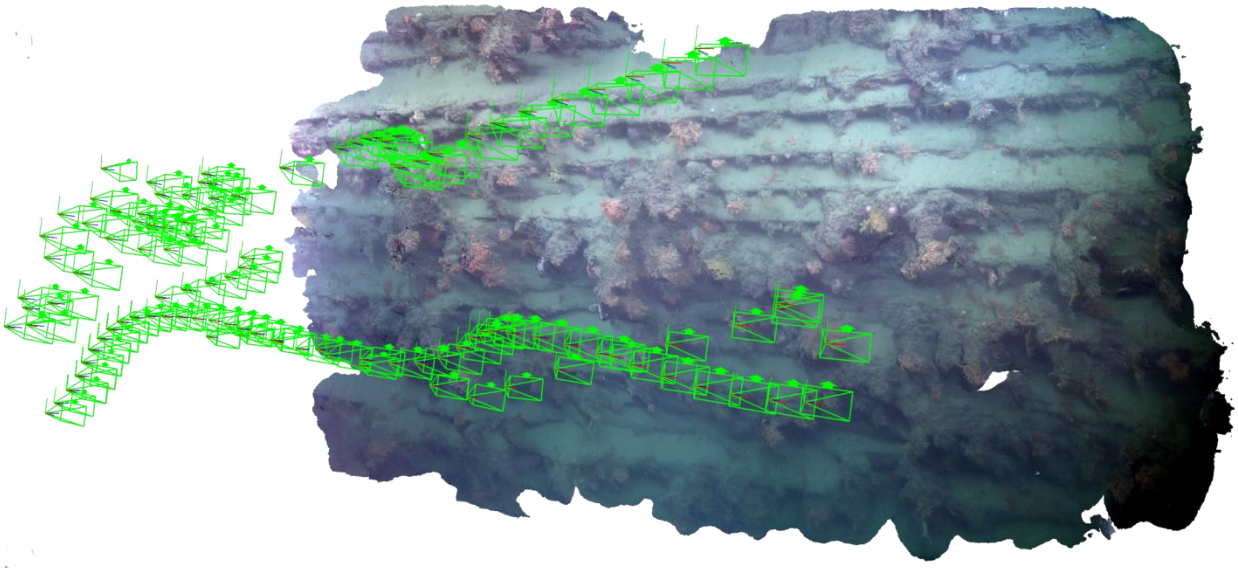


Figure: Photogrammetry reconstruction of a vertical wall in Whittard Canyon, Northeast Atlantic (1340 m in depth).

Remote Sensing Assessment of Seaweed Resources in Western Ireland

T. Rossiter[1, 2], G. Casal[2], T. Furey[2], T. McCarthy[3], D.B. Stengel[1]

1. Botany and Plant Science, School of Natural Sciences and Ryan Institute for Environmental, Marine and Energy Research, National University of Ireland Galway, Ireland
2. INFOMAR, Marine Institute, Rinville, Ireland
3. National Centre for Geocomputation, National University of Ireland Maynooth, Ireland

The aim of this work is to develop an innovative and multi-disciplinary approach to assess the distribution and biomass of both intertidal fucoids (*Ascoplyllum nodosum*) and subtidal kelps (Laminariales) which are both of commercial and ecological importance in Ireland. We look to address the current deficit of information about these Irish seaweeds, which will underpin sustainable resource development.

Aerial hyperspectral imagery is used to assess *A. nodosum* populations and will enhance species discrimination in a spatially and spectrally heterogeneous environment like the intertidal zone. Kelp habitat assessment will be done using a multibeam system (MBES) on a small vessel. Field surveys will be used to ground-truth both *A. nodosum* and kelp distribution, evaluate morphology, and estimate biomass.

An aerial survey (July 2016) was conducted in western Ireland (Galway Bay) to survey *A. nodosum* using a Cessna 172 mounted with a Multispectral AIRINOV AgroSensor and a OCITM-U-1000 Ultra Compact Hyperspectral Imager. The flight plan was designed to cover as much of the intertidal zone as possible. Field-based surveys have been conducted at multiple sites to match algal species presence, composition and biomass within the *A. nodosum* beds along with a field-radiometry survey, using a TriOS RAMSES radiometer, to construct a spectral library of species and substrate to classify the remote sensing data. To improve the accuracy of the *A. nodosum* assessment, ground-truthing data are being collected on-foot, using a hand-held GPS device (Garmin Montana 600), to support the classification process by underpinning the selection of training areas.

We present a detailed methodology for assessing the spectral response of *A. nodosum* in relation to biological and physiological parameters in its habitat and the challenges associated with the discrimination between species of the same genus. Small drones offer very high resolution colour imagery and will support the *A. nodosum* assessment by collecting ground-truthing data far more efficiently than on-foot methods.

High-Resolution, Habitat-Suitability Maps for the Conservation and Management of Vulnerable Marine Ecosystems on the Louisville Seamount Chain, South Pacific Ocean

A.A. Rowden[1], O.F. Anderson[1], S.E. Georgian[2], D.A. Bowden[1], M.R. Clark[1], A. Pallentin[1], A. Miller[3]

1. National Institute of Water & Atmospheric Research (NIWA), Wellington, New Zealand
2. Marine Conservation Institute (MCI), Seattle, United States of America
3. NIWA, Hamilton, New Zealand

Vulnerable marine ecosystems (VMEs) are ecosystems at risk from the effects of fishing activity or other kinds of disturbance, as determined by the vulnerability of their components (e.g., habitats, communities or species). Habitat suitability modelling is being used increasingly to predict distribution patterns of VME indicator taxa in the deep sea (where data are particularly sparse), and the models are considered useful for marine ecosystem management.

The Louisville Seamount Chain is located within the South Pacific Regional Fishery Management Organisation (SPRFMO) Convention Area, and some seamounts are the subject of bottom trawling for orange roughy by the New Zealand fishery. The aim of the present study was to produce high-resolution, habitat suitability maps for VME indicator taxa and VME habitat on these seamounts, in order to aid the design of within-seamount spatial closures to protect VMEs.

We used a multi-model habitat suitability mapping approach, based on bathymetric and backscatter data collected by multibeam echo sounder survey, and data for the stony coral and habitat-forming VME indicator species *Solenosmilia variablis* collected by towed underwater camera. Maps resulting from our models showed that suitable habitat for this species is distributed around the summit-slope break of seamounts, and along ridges that extend down the seamount flanks. Only the flat, soft sediment summits are predicted to be unsuitable habitat for this stony coral species. We translated a definition for stony coral-reef habitat into a *Solenosmilia variablis* abundance-based threshold in order to use our models to map this VME habitat. These maps showed that coral-reef occurred in small and isolated patches, with most of the seamounts predicted to be unsuitable habitat for this VME.

We discuss the implications of these results for spatial management closures on the Louisville Seamount Chain seamounts and the wider SPRFMO area, and future modelling improvements that could aid efforts to use habitat suitability maps for managing the impact of fishing on vulnerable marine ecosystems.

Historical Environmental Measurements Reveal Drastic Decrease on Baltic Sea Keystone Species

M. Sahla [1], L. Kurvinen [2], A. Ruuskanen [3]

1. Metsähallitus, Parks & Wildlife Finland, Vaasa, Finland
2. Metsähallitus, Parks & Wildlife Finland, Vantaa, Finland
3. Monivesi Oy, Finland

Human activities have been drastically reshaping the distribution of Baltic marine biotopes during the past 100 years. The Baltic Sea is especially vulnerable to human pressures due to its limited water exchange. A large variety of human activities occur in the marine areas. However some of the most notable pressures, such as eutrophication and increased sedimentation, can be traced to activities happening in the surrounding drainage areas. Eutrophication increases the amount of algal material in the water column, which together with suspended sediments can reduce the light penetration significantly. Light availability is crucial for benthic plants and therefor declining light penetration will result in deep areas becoming unsuitable for plant growth.

In this study we have combined new habitat modeling techniques and historical water quality data to show how changes in light availability have affected to the extent of favorable areas for bladderwrack (*Fucus spp.*), which is one of the most important keystone species in the northern Baltic Sea. This study is as far as we know the first attempt to quantify large scale change of favorable areas for bladderwrack using spatial analysis. We have found that decreased light availability at the seafloor has reduced suitable areas for *Fucus spp.* in Finnish coastal waters up to 60% during past 100 years. Similar trend has been found when examining long term surveillance data on maximum depth limits on *Fucus spp.* occurrence during the past decades.

We have been able to successfully map areas where large scale habitat degradation has been taking place. The results are being used in the assessment of Finnish Red List of Ecosystems and the methodology is applied for other biotopes as well. The resulting data can also be used when making conservation and restoration plans for marine areas. The importance of these findings lies in future planning. We know now what kind of status can again be achieved if sufficient protection measures are taken into action. We can also use this methodology to project future scenarios for habitat distribution with changes in salinity, nutrients, turbidity or even sea level rise.

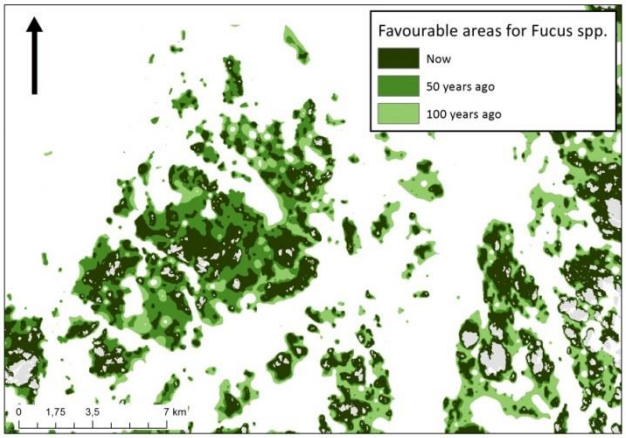


Figure 1. Favorable areas for *Fucus spp.* has been modeled for the whole Finnish coast with current and historical data.

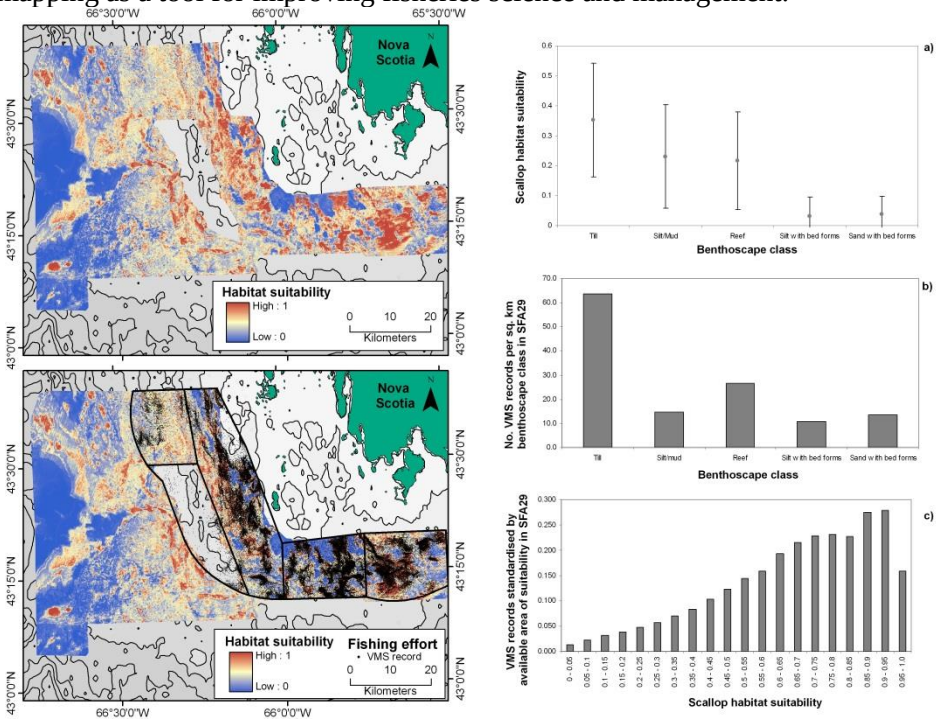
Habitat Mapping in Support of Improved Assessment and Management of Scallop Fisheries in the Maritimes Region, Canada

J.A. Sameoto[1], C.J. Brown[2], S.J. Smith[1]

1. Fisheries and Oceans Canada, Dartmouth, Nova Scotia, Canada
2. Applied Research, Nova Scotia Community College, Dartmouth, Nova Scotia, Canada

The importance of incorporating spatial information into the assessment and management of scallop populations has long been recognized. Due to the strong association between scallops and substrate type, scallop distributions can be relatively well represented by seafloor habitat maps. These maps, combined with geospatial fishery data, have tremendous potential to improve our understanding of the spatial patterns and complexities of scallop populations and their dynamics in response to fishing. Further, marine habitat maps provide spatial classification of patterns which can be used to understand ecosystem dynamics and support ecosystem-based fisheries management.

In the Maritimes Region of Atlantic Canada, the majority of commercial scallop fishing areas (SFAs) have been surveyed using multibeam echosounders (MBES). In 2010, a detailed underwater imagery survey was conducted in SFA 29W off south-west Nova Scotia and these data were subsequently modelled with MBES bathymetry, backscatter, and associated metrics to derive both a species-specific habitat map for the sea scallop, *Placopecten magellanicus*, and a benthoscape map of broad bio-physical characteristics of the seafloor. These habitat maps have subsequently been used to improve the understanding of scallop population dynamics, develop a habitat based population model, set biological reference points for fisheries management that incorporates habitat associations, and evaluate overlap between the fishery and benthic communities; all of which demonstrates the tremendous potential of habitat mapping as a tool for improving fisheries science and management.



Figures showing scallop habitat suitability map with and without fishing activity overlaid and comparisons between habitat maps and fishery overlap.

Implementing Sustainable Harvesting of Arctic Surf Clam in Atlantic Canada Through the Use of High-Resolution Seafloor Habitat Maps

M. Sarty[1], J. Mosher[1], V. Gazzola[2], C.J. Brown[2]

1. Clearwater Seafoods, Lunenburg, Nova Scotia, Canada
2. Applied Research, Nova Scotia Community College, Dartmouth, Nova Scotia, Canada

Clearwater Seafoods, founded in Nova Scotia in 1976, has grown into one of the world's leading seafood companies. The company's core philosophy is based on sustainability and stewardship at sea and onshore, recognizing that healthy oceans are fundamental to business success. The development and implementation of enhanced seafloor maps of fishing grounds, depicting predicted habitat distributions of target species, is one of Clearwater's primary objectives within their Harvest Science operations. These onboard visualizations contribute to the development of corporate resource-management frameworks for (1) sustainable stock assessment for the spatial regions, (2) improved offshore harvest efficiencies for the target species, and (3) significant reductions of the fishery's footprint on the ocean floor.

To contribute towards achieving these objectives, Clearwater Harvest Science has been collaborating with the Nova Scotia Community College to develop seafloor habitat maps for its clam fishery using multibeam echo sounder (MBES) data collected in 2007 and 2008 on Banquereau Bank, and more recently in 2016 on the Grand Banks of Newfoundland.

Here we demonstrate how MBES backscatter, bathymetry, and secondary-derived bathymetric layers (e.g. slope, curvature, etc.) have been used to model predictive habitat for Arctic Surf Clam (*Mactromeris polynyma*) – Clearwater's target fishery on the banks. Utilizing onboard visualization applications, Clearwater's Fishing Masters are able to target, with precise accuracy, the most preferred benthic areas of the banks.

Species Distribution Modelling (SDM) maps and images are being developed and continuously evaluated along with commercial catch data from the Clearwater Harvest Management database to demonstrate the credibility and validity of the maps and to measure the company's harvest efficiencies and subsequent performance measurement. SDM maps, along with backscatter and bathymetry information, have become important tools and are routinely used aboard Clearwater's clam fishing vessels to target fishing areas thus providing for sustainability of the ocean and resource, and the most efficient harvesting of quotas.

Although only in the early stages of the project, evidence from fishing performance over recent months have suggested that the use of this information can increase catch rates, reduce bottom contact of the fishing gear, and results in a significant increase in revenue from a fishing trip. For a quota-based fishery, this demonstrates the combined economic and environmental benefits these advanced seafloor habitat maps can offer.

A Three-Dimensional Mapping of the Ocean Based on Environmental Data

R.G. Sayre[1], D.J. Wright[2], S.P. Breyer[2], K.A. Butler[2], K. Van Graafeiland[2], M.J. Costello[3], P.T. Harris[4], K.L. Goodin[5], J.M. Guinotte[6], Z. Basher[1], M.T. Kavanaugh[7], P.N. Halpin[8], M.E. Monaco[9], N.A. Cressie[10], P. Aniello[2], C.E. Frye[2], D. Stephens[2]

1. United States Geological Survey, Reston, Virginia, USA
2. Esri, Redlands, California, USA
3. Institute of Marine Science, University of Auckland, Auckland, New Zealand
4. GRID-Arendal, Arendal, Norway
5. NatureServe, Arlington, Virginia, USA
6. United States Fish and Wildlife Service, Denver, Colorado, USA
7. Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA
8. Nicholas School of the Environment, Duke University, Durham, North Carolina, USA
9. National Ocean Service, National Oceanic and Atmospheric Administration, Silver Spring, Maryland, USA
10. National Institute for Applied Statistics Research Australia, University of Wollongong, Wollongong, Australia

Oceanographers have long recognized and described persistent, large, water masses which partition the global ocean into chemically and physically distinct volumetric regions. We constructed a regularly spaced ocean point mesh grid from sea surface to seafloor, and attributed these points with the 2013 World Ocean Atlas (WOA) dataset, version 2, 57 year average values for six physical and chemical environment parameters (temperature, salinity, dissolved oxygen, nitrate, phosphate, and silicate). The database of over 52 million points represented the global ocean in x, y, and z dimensions. These points were statistically clustered to define 37 distinct volumetric units, here called Ecological Marine Units (EMUs). The EMUs represent physically and chemically distinct water volumes based on spatial variation in the six marine environmental characteristics used. Twenty two of the 37 EMUs are globally or regionally extensive, and accounted for 99% of the ocean volume, while the remaining 15 were smaller and shallower, and occurred around coastal features. We characterized the horizontal and vertical dimensions of EMUs and mapped distinct marine regions of varying size and depth. We found vertical separation into three broad depth zones, and general spatial correspondence with the major global water masses. The EMUs are an open access resource, and are intended to be useful for disturbance assessments, ecosystem accounting exercises, conservation priority setting and marine protected area network design, and other research and management applications.

Habitat Mapping Towards an Ecosystem Approach in Marine Spatial Planning

K.S. Schiele[1], A. Darr[1], R. Pesch[2], B. Schuchardt[2], C. Kuhmann[3]

1. Leibniz-Institute for Baltic Sea Research Warnemünde, Germany
2. BioConsult Schuchardt & Scholle GbR, Germany
3. Federal Agency for Nature Conservation, Germany

Marine spatial planning (MSP) coordinates human activities at sea to avoid spatial conflict and to identify suitable space for these activities. Successful planning requires the best available data to base decision upon. Nevertheless, marine plans have been prepared without e.g. high resolution habitat or biotope maps being available for the planning area.

As the ecosystem approach has been widely adopted as an overarching principle of MSP, mapping of benthic biotopes has become even more relevant to identify areas of importance for nature conservation.

Our study provides a scientific basis for an ecosystem approach in MSP by 1) developing biotope maps, 2) identifying relevant areas/ spatial claims for nature conservation and 3) considering trans-national issues. We present work from the Baltic Sea and the North Sea focusing on offshore waters.

The maps illustrate the distribution of benthic species, habitats and biotopes according to different levels in the regional classification systems (EUNIS or HELCOM Underwater Biotope classification system). Regional applicability and comparability of classification systems is of special relevance e.g. to identify stepping stones in biotope networks that extend to the waters of neighboring countries.

Areas where protected species and biotopes occur are evaluated in terms of ecological importance (hot-spot for the species, size, ecological condition). The most important areas are identified as spatial claims for nature conservation. While a broad overlap of these areas with already designated MPAs confirm their relevance, additional areas outside the borders of MPAs were identified. This finding highlights the importance of MSP for nature conservation.

Based on current research we provide scientific information translated into spatial claims for nature conservation to be considered in an integrated ocean management. Planners and decision makers are enabled to make more informed choices and thus reaching better decisions.

Quality of Image-Based Manganese Nodule Abundance Assessment

T. Schoening[1], J. Greinert[1]

1. GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany

Manganese nodules are a marine mineral resource and are considered for deep sea mining operations. These nodules constitute an important element of the deep sea habitats they occur in and their abundance and size frequencies have an impact on occurring fauna. Assessing the distribution of nodules is traditionally done with a combination of large-aerial hydro-acoustic mapping linked with ground-truthing by physical sampling. While hydro-acoustics provide large aerial coverage (km^2/h) with low resolution (m/px), physical sampling provides low aerial coverage (cm^2/h) with high resolution (mm/px). To bridge these two separate data domains, optical imaging has successfully been applied as it provides medium aerial coverage (ha/h) and resolution (cm/px).

Extracting quantitative data from optical images is traditionally done by effortful manual image annotation. More recently, multiple automated and semi-automated image analysis algorithms have been proposed. These algorithms are usually tuned for one specific data set or use case. The application of these algorithms to other optical imagery data sets is one necessity to prove their robustness. As manual annotations of manganese nodules are scarce and focus on nodule counts rather than exact nodule delineations, quantitative assessment of the quality of detection algorithms in the form of e.g. precision and recall is not possible at the moment.

Apart from the within-data comparison, a link to the traditional sampling strategies is required. These strategies are the de-facto standard for aerial mapping of habitats and assessing seafloor substrate composition (including manganese nodules). In the case of physical sampling, statistic variations in the natural nodule abundance can bias the sampling outcome. In the case of hydro-acoustic sampling, small-scale natural variations in abundance that are relevant to mining as well as habitat composition can be occluded due to the limited resolution. Using optical imaging as a bridge technology enables to extract more robust nodule abundance data.

This presentation will include results on comparing different nodule detection algorithms, and will show the challenges in correlating physical sampling derived data with optical imagery data and shows potential applications for habitat assessment using the presented algorithms.

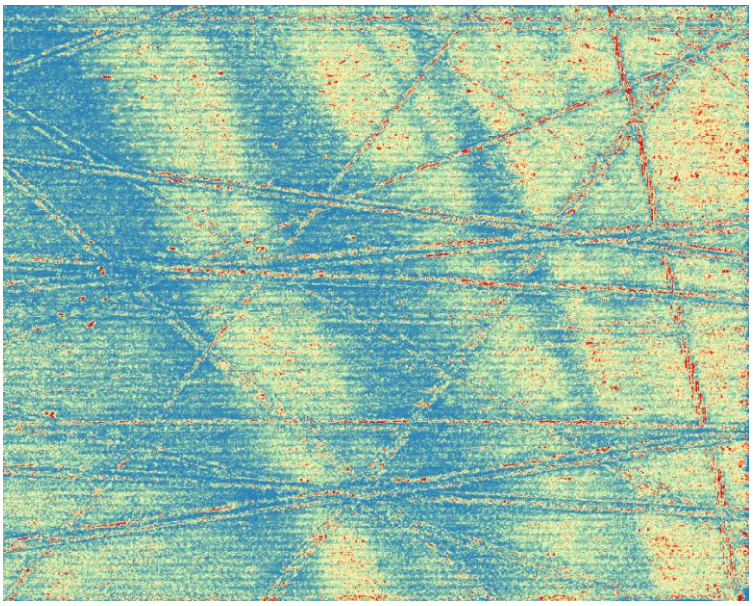


Figure 1: Nodule coverage of the seafloor (in %) within the central DISCOL Experimental Area in the Peru basin. An area of 500x400m has been optically mapped entirely. The nodule abundance assessment was conducted at a resolution of 0.25x0.25cm^2/px. The nodule abundance follows the bathymetric variations of less than 5m. Physical disturbances of the seafloor in the form of linear plough marks are clearly visible, scattered throughout the entire area.

Glacial and Postglacial Landforms and Processes adjacent to King William Island, Nunavut, Canadian Arctic Archipelago

J. Shaw[1], B.J. Todd[1]

1. Geological Survey of Canada, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada

The subaerial morphology of coastal King William Island and the bathymetry of adjacent offshore channels of the Canadian Arctic Archipelago have been explored with terrestrial/marine LiDAR and multibeam sonar surveys. During the Late Wisconsinan, the Laurentide Ice Sheet extended northward across most of the Canadian Arctic and imprinted the buried landscape. Analysis of the survey data elucidates both glacial and postglacial processes that have shaped the seafloor in channels of the south-central Canadian Arctic Archipelago.

Glacial landforms include multiple, parallel, elongated, ridges many kilometres in length (mega-scale glacial lineations), and fields of drumlins; both of these features are indicative of ice flow direction, generally to the north. During ice sheet retreat, eskers and tunnel valleys formed beneath the ice and swarms of icebergs were released at the calving front. The keels of numerous icebergs incised the seabed with a pattern of furrows flanked by berms; these iceberg ploughmarks provide insight into paleocurrent directions in the archipelago during glacial retreat. Iceberg ploughmarks subaerially exposed on King William Island indicate a formerly higher sea level than at present.

Postglacial landforms include raised beaches on King William Island, formed during the lowering of sea level to its present elevation. Extensive fields of small seabed pockmarks, 2 to 3 m in diameter, were likely formed by the release of gas within the sea floor sediment. A biogenic or petrogenic source for the gas has yet to be determined. Enigmatic, flat-bottomed pits, about 30 m in diameter, may be strudel scour or may be also related to gas release.

Work is continuing to determine if Hexactinellid sponge reefs populate Victoria Strait west of King William Island. The seabed morphology in Victoria Strait strongly resembles that of sponge reefs mapped in the Pacific Ocean off British Columbia, where these reefs preferentially grow on ridges of coarse-grained glacial deposits exposed on the seabed.

Insights from the PharmaDEEP Expedition to the South Shetland Trench in the Sub-Antarctic

H.A. Stewart[1], A.J. Jamieson[2]

1. British Geological Survey, The Lyell Centre, Edinburgh, UK
2. School of Marine Science and Technology, Ridley Building, Newcastle University, UK

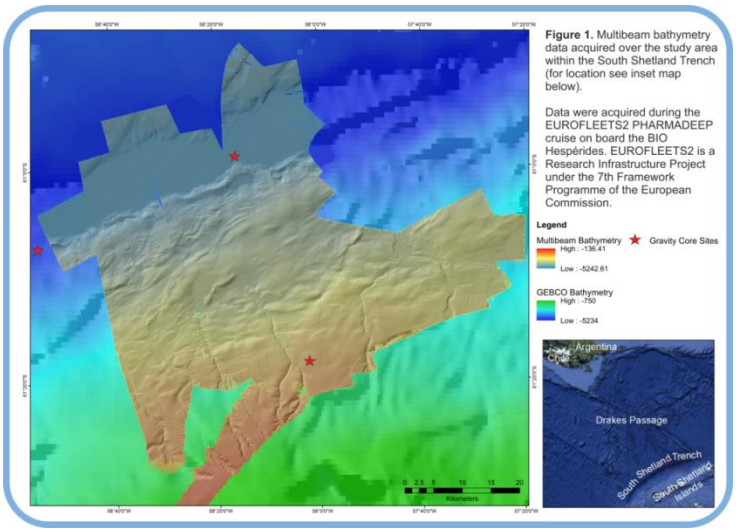
The PharmaDeep Expedition was a EUROFLEETS2 funded project that combined traditional marine biological and geological exploration with the search for new bacterial 'extremophile' communities in the quest for the next generation of pharmaceuticals.

The South Shetland Trench, located near the Antarctic Peninsula, is one of the few cryogenic, deep-sea trenches in the world. The Expedition aimed to collect marine organisms from deep-and-cold-water habitats which may prove valuable pharmaceutical potential; to perform the first known biological and geological survey of the South Shetland Trench; and to compare the fauna and drivers controlling their distribution to other trench ecosystems.

Between the 13th and 29th December 2015, 14 researchers from a range of disciplines sailed on the Spanish research vessel *BIO Hesperides*. The operational scientific days allocated to the project totalled 6 days during which time 4 baited lander deployments, 8 gravity core sites, 2 multi-cores, 3 beam trawls, 10 zooplankton hauls and 19 phytoplankton hauls were conducted. Additionally, 3148 km^2 of multibeam echosounder data and around 600 line kilometres of Topas sub-bottom data were acquired covering part the southern flank and trench floor of the study area.

Although the expedition objectives were met, this was not without its challenges, including permitting, a shortage of bunks, weather, sampling troubles, an inordinate number of icebergs and Christmas.

We will present some of the technical and logistical challenges encountered working in this remote environment and summarize some of the key findings from the expedition.



Glacigenic Debris-Flows and Down-Slope Gullies: Evidence of a Grounded Ice Margin During Past Glacials, South Shetland Trench, Antarctica

H.A. Stewart[1, 2], A.J. Jamieson[3], C. Ó Cofaigh[4], T. Bradwell[2]

1. British Geological Survey, The Lyell Centre, Edinburgh, UK
2. Biological and Environmental Sciences, School of Natural Sciences, University of Stirling, UK
3. School of Marine Science and Technology, Ridley Building, Newcastle University, UK
4. Department of Geography, Durham University, South Road, Durham, UK

The South Shetland Trench (SST) is located near the Antarctic Peninsula, around 100 km northwest, and parallel to, the South Shetland Islands. Although a number of studies examining glacial history have been undertaken in the Bransfield Strait located between the South Shetland Islands and the Antarctic Peninsula to the south, the authors believe this is the first study of the seafloor glacial geomorphology, and recent glacial history of the SST. This paper presents initial results from a EUROFLEETS Expedition to the SST that took place in December 2015.

The Expedition collected three gravity cores, 3148 square kilometres of multibeam echosounder data and around 600 line kilometres of Topas sub-bottom data covering part of the southern flank and trench floor of the study area. Additional bathymetry data derived from the Global Multi-Resolution Topography (GMRT) Synthesis (Marine Geoscience Data System www.marine-geo.org) comprising a multi-resolution global Digital Elevation Model (DEM) that includes processed multibeam bathymetry data (100 m resolution) where available and gridded seafloor depths (30 arc-second resolution) derived from the General Bathymetric Chart of the Oceans (GEBCO www.gebco.net). These combined data reveal the study area, north of King George Island, on the southern flank of the SST to host a system of linear downslope gullies, glacigenic debris flows and glacigenic deposits.

Within the study area glacigenic debris flows are found to extend from the continental shelf break to the lower continental slope. Sub-bottom profiler data penetrated up to 150 ms below seafloor in places and reveal a stacked sequence of debris flows suggestive of a fluctuating ice front that was grounded to, and retreated from, the shelf break on several occasions.

More than eleven individual gullies (and their tributaries) were imaged between 450 m and 3600 m water depth. The gullies are incised up to 250 m below the surrounding sea bed with internal slope angles locally exceeding 45° and were influenced by shallow transform faulting related to subduction processes.

Downslope gullies have been observed on other glaciated margins such as the Scotian slope offshore Canada, Ross Sea Antarctica, north-western Barents Sea and West Shetland Margin offshore north-western UK. The gullies are inferred as being eroded by turbidity currents comprising cold, dense, sediment-rich meltwater released from an ice front located at or near the continental shelf break.

Application of Detailed Mapping of Seafloor in Identification and Assessment of Environmental Conditions of the Southern Baltic Sea

K. Szefler[1], S. Rudowski[1], R. Wróblewski[1], Ł. Gajewski[1]

1. Maritime Institute in Gdańsk, Poland

Nowadays, application of integrated sets of non-invasive methods allows thorough identification of geological and topographical features of the seafloor as well as the production of sharp cartographic images. Opportunities offered by this method were presented on the example of a fragment of morainic seafloor from the southern Baltic Sea with relics of a moraine and with modern abrasive and accumulative seabed formations. Results of MBES and SSS measurements were elaborated in the form of bathymetric and geomorphological charts. There were presented also profiles and cross-sections obtained in the course of MBES and SES measurements as well as images of the seafloor surface based on SES measurements and images of smaller forms, e.g. ripple marks, sand waves and other forms recorded with use of ROV TV. The measurements conducted in the survey polygon constitute a preliminary stage to the works that are to be performed over bigger areas and which are associated with i.a. habitats and monitoring of condition and changes in the seafloor generated by natural and anthropogenic impact (such as laying of cables and construction of wind turbines).

Nationwide Mapping of Coastal Resources in the Philippines Using Remote Sensing

A. Tamondong[1], C. Cruz[2], K.D. Ticman[2], G.A. Go[2], R. Peralta[2], M.V. Vergara[2], I.E. Cadalzo[2], M.S. Estabillo[2], R. Jalbuena[2], R.R. Quides[2], A. Songcuan[2], A. Blanco[1]

1. University of the Philippines Department of Geodetic Engineering, Philippines
2. Phil-LiDAR 2, UP Training Center for Applied Geodesy and Photogrammetry, Philippines

The Philippines is an archipelagic country with approximately 7,100 islands and 36,000 kilometres of coastline. Many of its people depend on coastal resources for daily necessities such as food. Due to population growth and industrialization, the coastal environment and its resources are being threatened. Integrated management is widely recognized as the basis for sustainable use and to achieve this, an evaluation and mapping of the resources is needed. Inventory of these resources provide important baseline data for resource management which can help in decision making in planning and development. Using the traditional method of field sampling to map these resources will be too difficult, time consuming and expensive. With the latest technologies such as remote sensing, mapping the coastal resources of the Philippines is not too farfetched.

The University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP) funded by the Department of Science and Technology (DOST) has recently embarked in a project (CoastMap) which will enable the mapping of coastal resources in the country. The main objective of CoastMap is to map the high valued coastal resources such as benthic habitats, mangroves and aquaculture of the Philippines. To be able to do that, different workflows were developed, tested, and assessed for extraction of such resources using LiDAR, Landsat and WorldView-2 and aerial imageries for pilot sites which will then be applied to other data available for the whole country. Another objective of the project is capacity building. The CoastMap team was tasked to conduct trainings on basic remote sensing and GIS to the fifteen partner SUCs and HEIs, cascade the workflows the team developed and monitor their progress. Each partner was tasked to map the coastal areas near their location.

The CoastMap team was able to develop the following methods for its objectives: object-based image analysis for benthic habitat mapping using LiDAR derivatives, object-based image analysis for extracting aquaculture classes using LiDAR datasets, object-based image analysis for extracting mangroves using LiDAR and orthophoto datasets, extraction of coastal aquaculture features (fish ponds, fish pens, fish cages extraction) from high resolution WorldView-2 satellite images using object-oriented approach, object-based image analysis for benthic habitat mapping using high resolution WorldView-2 satellite images and mangrove mapping from Landsat images.

In the extraction of coastal resources from remotely sensed data, field surveys to collect training and validation points are done in order to calibrate the classification processes and validate the resulting maps. The ground data collected aids in the assessment of the quality of the extracted information. The project employs various methods of field data collection in order to produce detailed maps of the coastal resources. Included in these methods are ocular inspections, GPS location sampling, and underwater video tows.

Using AUV for Sediment Mapping – Experiences from a MAREANO Pilot Project, Norway

T. Thorsnes[1], L. Bjarnadottír[1], F. Jakobsen[1], V. Bellec, M. Dolan[1], P. Lågstad[2], K.T. Olsen[3]

1. Geological Survey of Norway (NGU), Norway
2. Norwegian Defence Research Establishment
3. Norwegian Hydrographic Service, Norway

Sediment grain-size maps are an important product in their own right and a key input for habitat and biotope maps. National and regional mapping programmes are tasked with mapping large areas, and survey efficiency, data quality, and resulting map confidence are important considerations when selecting the mapping strategy. Since 2005, c. 175,000 square kilometres of the Norwegian continental shelf and continental slope has been mapped with respect to sediments, habitats and biodiversity, and pollution under the MAREANO programme (www.mareano.no). At present the sediment mapping is based on a combination of ship-borne multibeam bathymetry and backscatter, visual documentation using a towed video platform, and grab sampling.

We have now tested a new approach, using an Autonomous Underwater Vehicle (AUV) as the survey platform for the collection of acoustic data (Synthetic Aperture Sonar (SAS), EM2040 bathymetry and backscatter) and visual data (still images using a TFish colour photo system). This pilot project was conducted together the Norwegian Hydrographic Service, the Institute of Marine Research (biology observations) and the Norwegian Defence Research Establishment (operation of ship and AUV).

The test site reported here is the Vesterdjupet area, offshore Lofoten, northern Norway. The water depth is between 170 and 300 metres, with sediments ranging from gravel, cobbles and boulders to sandy mud. A cold-water coral reef, associated with bioclastic sediments was also present in the study area.

The presentation will give an overview of the main findings and experiences gained from this pilot project with a focus on geological mapping and will also discuss the relevance of AUV-based mapping to large-area mapping programmes like MAREANO.

Multi-Scale Harmonized Geological Maps of the European Seas – Third Phase of the EMODNET-Geology Project

H. Vallius[1] and EMODnet – Geology partners

1. Geological Survey of Finland (GTK)

Accelerating increase in marine and maritime activities around the globe are highlighting the amount of conflicting economic and environmental interests and the necessity of good tools for spatial planning of the maritime areas. Similarly there is a need to support the objectives to achieve Good Environmental Status in Europe's seas by 2020, set up by the European Commission's Marine Strategy Framework Directive. Consequently the European Commission established the European Marine Observation and Data Network (EMODnet), which is now in the beginning of its third phase (2017–2018, with an option of 2 more years). It is designed to assemble existing but fragmented and partly inaccessible marine data and to create interoperable, contiguous and publicly available information layers which are interoperable and free of restrictions on use, and which encompass whole marine basins.

The whole package of separate EMODNET- projects (lots) covers the marine disciplines geology, chemistry, biology, bathymetry, seabed habitats, physics and human activities as well as sea basin check-points from all European regional seas.

The third phase of the EMODnet-Geology project will deliver integrated geological map products that include seabed substrates, sediment accumulation rates, seafloor geology including lithology and stratigraphy, coastal behavior, geological events such as submarine slides and earthquakes as well as marine mineral resources and as a new feature map products on submerged landscapes of the European continental shelf at various time-frames. All new map products will have a resolution of 1:100,000 all over but finer where the underlying data permit. A multi-scale approach will be adopted whenever possible.

There will be a close cooperation between the EMODnet lots. To begin with the seabed substrate maps produced by the EMODnet geology lot will be transferred to the EMODnet seabed habitats lot as soon as they are ready. Geomorphology will be a topic for cooperation between the EMODnet geology lot and the high resolution seabed mapping project (EMODnet bathymetry).

How Subsurface Voxel Modelling and Uncertainty Analysis Contribute to Habitat-Change Prediction and Monitoring

V. Van Lancker[1], L. Kint[1], G. Montereale-Gavazzi[1,2], N. Terseleer[1], V. Chademenos[2], T. Missiaen[2], R. De Mol[3], G. De Tré[3], S. van Heteren[4], P.P. van Maanen[4], J. Stafleu[4]

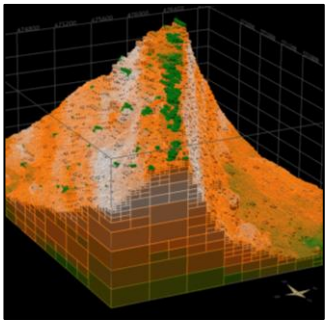
1. Royal Belgian Institute of Natural Sciences, Operational Directorate Natural Environment (RBINS), Belgium
2. Ghent University, Department of Geology, Renard Centre of Marine Geology, Belgium
3. Ghent University, Department of Telecommunications, Database, Document and Content Management, Belgium
4. TNO – Geological Survey of the Netherlands, The Netherlands

For long-term predictions of geological resource quantity and quality, a voxel model was built for the subsurface of the Belgian part of the North Sea (Belgian Science Policy 'TILES'). The 3D voxels contain lithostratigraphic information over the entire data volume (up to -70 m), but also sediment characteristics and a suite of sediment-dynamic parameters in the upper voxel (i.e., the seabed). Derivative data products include probability maps of sediment type and resource-suitability maps that reflect a combination of user-specific criteria.

From stakeholder consultation, it became clear that the model has numerous potential applications, provided that resolution requirements from very small-scale to large-scale can be met (e.g., assessing local aggregate quality, but also decision-making on long-term resource use). To accommodate these varying needs, and also to enhance computational speed, voxel models were post-processed to vary the size of the voxels dependent on user demand. As such, data density, but also geological heterogeneity can steer the voxel size.

Uncertainty is parameterised to generate data products with confidence limits. Uniquely, the quality of each of the data fields in the databases is quantified in order to be propagated in the voxel model. Additionally, interpolation-related uncertainty, as well as uncertainty in the mapping of the lithological class and stratigraphic uncertainty (i.e. the geological layer to which a so-called lithoclass belongs) is incorporated. Visualisation of these uncertainties is highly challenging, and is addressed through variation in the sizes of the voxels or through transparency.

An ample spectrum of benefits exists for habitat mapping. Firstly, the geology of the shallow subsurface is accounted for, being highly relevant in predicting and constraining habitat change in long-term projections of resource use. The approach is also pertinent to assist present-day seabed mapping. Uncertainty mapping is critical to judge on the accuracy of seabed maps, and it assists in interpreting habitat changes within an envelope of natural variability, imposed by both the geological nature of the seabed and the highly dynamic sedimentary environment.



Left: Marine aggregates as extracted from sandbanks. Right: Variable-size voxel model of a sandbank. The colour indicates suitability for medium sands (greyish: highest suitability; green: lowest suitability). Voxel size provides a broad indication of data uncertainty. Small voxel sizes at the surface are indicative of the highly detailed bathymetrical data layer; voxel sizes in the subsurface are here a function of borehole density.

Challenges of Biodiversity Inventories in Mosaic Archipelagoes – A Case Study from the Northern Baltic Sea

M. Viitasalo[1], P. Blankett[2], J. Ekebom[3], J. Hämäläinen[4], M. Kallasvuo[5], A. Kaskela[4], M. Koskelainen[1], K. Kostamo[1], A. Kotilainen[4], L. Kurvinen[3], M. Sahla[3], E. Virtanen[1], M. Westerbom[3], and VELMU Programme participants

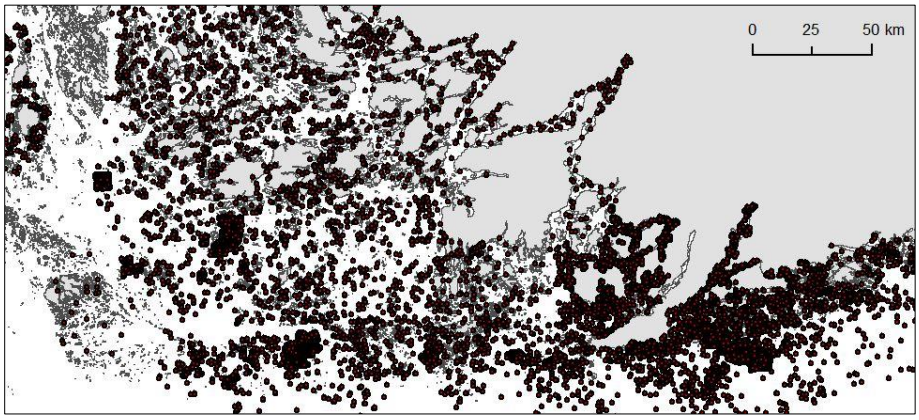
1. Finnish Environment Institute SYKE, Finland
2. Ministry of the Environment, Finland
3. Parks & Wildlife Finland
4. Geological Survey of Finland
5. Natural Resources Institute LUKE, Finland

The mosaic archipelagoes, high water turbidity, variable benthic habitats and very long shoreline of the Northern Baltic Sea make it costly and technically challenging to collect data that is useful for decision making concerning conservation and sustainable use of the marine environment.

The Finnish Inventory Programme for the Underwater Marine Environment (VELMU) has gathered information on species, communities and habitats during 2004-2016 from over 122,000 observation points. The data consists of 95,600 points made with drop-video or ROV, 23,200 with dive line points (from ca. 2000 dive sites), 1850 fish larvae sampling sites, >1000 benthos samples, 780 geological sediment samples, and 20,000 km of acoustic profiling (e.g. echosounding). In addition, satellite observations, LIDAR, aerial imaging with drones and automatic video platforms were used or tested. The majority of the data has been published in an open map service (https://paikkatieto.ymparisto.fi/velmu).

We present our national sampling design, by which the majority of data was collected cost-effectively in a 5 year time span (2011-2015). We show examples of our results, such as geographical distribution maps and spatial models for species, habitats, biodiversity and environmental factors. We also explain how the VELMU data has been used in marine spatial planning in the Finnish sea area. In the planning process, areas with high nature values were identified and given a high conservation priority, while other areas were identified as more suitable for human activities, such as aquaculture, wind energy production and ecotourism.

Based on our 13 years long experience we review the challenges of mapping species and habitats in complex marine environments, and provide a checklist for establishing a successful inventory programme in such conditions.



Map showing the amount of video observation sites of the VELMU Programme in SW Finland. Light grey: land, white: water, black dots: drop video or ROV video sites.

Novel Method to Predict Hypoxia in Shallow, Complex Archipelagoes

E. Virtanen[1], A. Norkko[2], M. Viitasalo[1]

1. Finnish Environment Institute, Marine Research Centre, P.O. Box 140, Helsinki, Finland
2. Tvärminne Zoological Station, University of Helsinki, Hanko, Finland

Hypoxia is a common phenomenon in marine areas characterized by strong water stratification and high organic production. These conditions are common in archipelagoes and estuaries around the world, especially in semi-enclosed marine areas, such as the Baltic Sea, the Black Sea and the Caspian Sea.

In complex archipelagoes, restricted water exchange is one of the main reasons for hypoxia. We tested if hypoxia can be predicted through a limited number of simple topographical features in the marine landscape. We modelled the potential for hypoxic bottoms and hypoxic-prone areas in the northern Baltic Sea, in a complex Finnish archipelago. Hypoxia was largely explained by enclosed topography and limited wave-force.

The modelling results show that large part of the variation of oxygen can be predicted without any knowledge of oceanographic parameters, temperature development, nutrient loading, biological communities, or biogeochemical processes in the sediment. Our model was validated with benthos samples with good results, matching with areas with poor bottom-fauna diversity. Our approach shows that areas prone to hypoxia can be identified by using simple topographic information. The method can also be used to assess where hypoxia is naturally occurring and where it is human-induced, and the potential for occurring in the future if environment resulting in hypoxia changes. Information can be used for deciding where eutrophication mitigation actions should be placed in a cost-effective way.

Mapping of the Major Morphologic Features and Seafloor Sediments of the New Hampshire Continental Shelf Using the Coastal and Marine Ecologic Classification Standard (CMECS)

L. Ward[1], Z. McAvoy[1], E. Nagel[1]

1. University of New Hampshire Center for Coastal and Ocean Mapping/Joint Hydrographic Center, New Hampshire, USA

The New Hampshire continental shelf is extremely heterogeneous and includes extensive bedrock outcrops, sand and gravel deposits, and muddy basins. Many of the depositional features are glacial in origin and have been significantly modified by marine processes as sea level fluctuated since the end of the last major glaciation. Glacial deposits (e.g., drumlins) on the shelf have been eroded, leaving very coarse lag deposits, while supplying sand to develop wave-formed features (shoals). Many of these features have positive relief standing above the seafloor, lending evidence of their formation by waves and shallow water currents. Some of these deposits may represent significant sand and gravel deposits and have the potential for future use for beach nourishment and other efforts to build coastal resiliency.

Relatively recent high resolution multibeam echosounder (MBES) bathymetric and backscatter surveys have revealed features of the New Hampshire shelf and vicinity seafloor in exceptional detail that has not been previously described. Synthesis of the MBES bathymetry and backscatter (along with bathymetric derivatives), coupled with an extensive archived database consisting of subbottom seismics, bottom sediment grain size data, and vibracores, were used to develop new surficial geology maps based on CMECS (partially supported by the Bureau of Ocean Energy Management). The new surficial geology maps of the New Hampshire shelf produced in ArcGIS represent a major improvement over previous mapping efforts and provide ground truth for testing automated classification approaches. Presently, the CMECS maps are being refined and the classification of the geoforms expanded for paraglacial environments. In addition, automated characterization and segmentation approaches using QPS Fledermaus Geocoder Toolbox Angle Range Analysis (ARA) and ESRI ArcGIS Spatial Analyst Tools are being evaluated.

Using Topo-Bathymetric LiDAR to Map Near Shore Benthic Environments

T.L. Webster[1], K. McGuigan[1], N. Crowell[1], N. Fee[1]

1. Applied Geomatics Research Group, Nova Scotia Community College, Nova Scotia, Canada

The Chiroptera II shallow water topo-bathymetric LiDAR sensor has been used to survey several coastal areas in Maritime Canada since 2014. In addition to the production of seamless elevation models, the green laser reflectance amplitude has been used in combination with the seabed roughness to map seagrass beds. The LiDAR is coupled with a 5 MPIX quality assurance camera and a 60 MPIX RCD30 multispectral camera (RGB+NIR). Utilizing the camera information with the LiDAR derivatives has allowed us to improve our bottom mapping capabilities and expand the number of benthic classes that can be derived. The amplitude of the green laser, 515 nm, decays exponentially with water depth. The strength of the signal is dependent on several factors including: water surface specular reflection, local incidence angle (scan angle + aircraft orientation), water column properties and the seabed material. We have developed a method to normalize the amplitude of the green laser points between flight lines. The energy of the light exponentially decays with depth and the amplitude of the signal is not scaled accordingly. We have developed an empirical method to depth normalize the amplitude image so it can be used in image classification.

We will present various classification methods using the LiDAR and photo derived products to map the benthic environment. These methods include: semi-empirical, pattern recognition (maximum likelihood, k-means), machine learning such as random forest and object based segmentation. The results are validated using drop camera point based ground truth or echosounding data from a Biosonics system. We will also present research related to extracting attributes directly from the waveform of the green laser return that offers additional potential for habitat classification.

Seabed Mapping: Critical Needs and Potential Application in China offshore

P. Yin[1], K. Cao[1], J.Q. Liu[1], S.Y. Ye[1]

1. Qingdao Institute of Marine Geology, China Geological Survey (CGS), China

China has an 18,000 km continental coastline, more than 6500 islands and the marginal seas have wide continental shelves. In addition, large rivers such as the Yellow River, Yangtze River and Pearl River, and other small rivers, discharge around 1.39×10^9 tons of suspended sediment into the China Sea making the coast and continental shelf a prime fishery and host a variety of ecosystems.

Anthropogenic impacts, including through fishing activities, have dramatically changed the Chinese coastal and offshore ecosystem in the last 50 years. Trawlers used in offshore benthic fishing, affect the seabed surface and as a result the recovery of the benthic ecosystem is under threat. It is estimated that sea-grass coverage has decreased by over half, the dominant benthic species has changed and biomass has decreased even though the biodiversity has stayed relatively stable. China has setup sixty-nine state marine natural reserves and forty-five marine special reserves during the past thirty years and most of them focus on the ecosystem protection. Artificial reefs were deployed to help the rehabilitation of benthic biomass near the coast and islands, although the practices need further assessment for better implementation in the future.

The China Geological Survey is conducting a coastal and offshore mapping program intended to support the development of coastal and offshore resources and environment protection, including ecosystem assessment and recovery. Seabed mapping combining geological and biological methodologies should be taken into account, especially in those areas with intensive anthropogenic activities, such as fishing, land reclamation, and coastal and seabed engineering projects. The East China Sea coast and offshore areas are a key study area for geological and biological seabed mapping, and also face the challenge of high turbidity of sediments in the water column. Suitable seabed mapping tools and technologies need to be selected and implemented in the offshore mapping project. The interpretation and knowledge transfer to society beyond geology should also be implemented in the future.

Assessing Impacts of Changing Ocean Conditions on Three Nearshore Foundational Species

M.A. Young[1], D. Ierodiaconou[1]

1. Centre for Integrative Ecology, Department of Life and Environmental Sciences, Deakin University, Australia

Climate change is having far reaching impacts across the globe but there is a still a lot of uncertainty in how ecosystems are responding. This uncertainty is much greater in marine ecosystems where our understanding lags behind that of terrestrial ecosystems. Despite this lag in understanding, marine environments are changing at rapid rates and there is a need to study the effects of how changes in ocean conditions are affecting marine ecosystems. Most studies in the past have looked at how temperature fluctuations are shifting the abundance and distribution of species; however, climate change is also impacting other aspects of the ocean including circulation and the wave environment. Taking into account all of these changes in the marine environment and focusing on species that are important and foundational members of the community can give insight into how marine ecosystems are likely to respond to climate related changes. In this study, we looked at three species that structure the nearshore environment and their responses to variations in habitat and oceanic conditions along the Southeast coast of Australia. With rises in ocean temperatures exacerbated by the strengthening of the East Australian Current, the water off the coast of Southeast Australia is experiencing rapid warming, causing this region to be a hotspot for ocean temperature change. To assess ecosystem response to these changes, we investigated two species of habitat forming kelps (*Ecklonia radiata* and *Pyllospora comosa*) and an ecosystem engineer (blacklip abalone, *Haliotis rubra*). Using long-term data (2003-2015) on *E. radiata* and *P. comosa* percent cover and *H. rubra* biomass collected using diver transects across 180 sites along the coast of Victoria, Australia, we assessed the relationship between these species and environmental drivers. These environmental drivers included seafloor habitat characteristics, hydrodynamic information that was downscaled to 500 m resolution and hindcasted over the past 20 years (wave orbital velocities, wave power, significant wave height, current speed, current direction) and annual and seasonal sea surface temperature data from 2003–2015. We also incorporated annual catch data to account for abalone population decreases due to commercial fisheries. We then related all these variables in generalized linear mixed effects models (GLMM) for each species with year and sites as random effects. The results from the GLMMs show that these three species have strong habitat associations and complex interactions with changes in sea surface temperature and the hydrodynamic environment. For example, the subsurface kelp species tend to have a negative response to warming temperatures but this response can be buffered by increasing or consistent wave exposure. Overall, this study helps us to understand the combined effects of habitat and changing oceanographic conditions on these three species, which will help to facilitate management of these ecologically and economically important nearshore marine ecosystems.