MESOPP

MESOPP Workshop

University of St Andrews, St Andrews, Scotland, United Kingdom

7-9 June 2017

User Requirements for a Central Information System (CIS) on the acoustic-based observation-modelling system

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1. Overview

MESOPP (Mesopelagic Southern Ocean Prey and Predators) is a European H2020 International Cooperation project to enhancing and focusing research and innovation cooperation with Australia. The underlying concept of MESOPP is the creation of a collaborative network and associated e-infrastructure (marine ecosystem information system) between European and Australian research teams/institutes sharing similar interests in the Southern Ocean and Antarctica, its marine ecosystem functioning and the rapid changes occurring with the climate warming and the exploitation of marine resources.

In the past 30 years, facing global knowledge issues, lacking data, addressing huge modelling challenges, we observed the successful world organisation of meteorology. These past 15 years, Europe has kick started and demonstrated similar successful structuring of the operational oceanography fostered by the Copernicus initiative (http://marine.copernicus.eu/), today worldwide used and recognised, fully anticipated and integrated in GOOS (Global Ocean Observing System), IOSS (Integration ocean observation system), SOOS (Southern Ocean Observing System), GODAE (the international global ocean data assimilation experiment), and IMBER (integrated marine biogeochemistry and ecosystem research).

A major R&D strategic challenge is to connect the marine ecosystem community across the fields of meteorology, climate, oceanography and biology. Lack of data, development of accurate high end models, global coverage and need for exchange are issues that need to be overcome.

While MESOPP will focus on the enhancement of collaborations by eliminating various obstacles in establishing a common methodology and a connected network of databases of acoustic data for the estimation of micronekton biomass and validation of models, it will also contribute to a better predictive understanding of the SO based on furthering the knowledge base on key functional groups of micronekton and processes which determine ecosystem dynamics from physics to large oceanic predators. This first project and associated implementation (science network and specification of an infrastructure) should constitute the nucleus of a larger international program of acoustic monitoring and micronekton modelling to be integrated in the general framework of ocean observation following a roadmap that will be prepared during the project.

Partners

- CLS, Collecte Localisation Satellites, France
- CSIRO: Commonwealth Scientific and Industrial Research Organisation, Australia
- UTas: University of Tasmania, Australia
- AAD: Australian Antarctic Division, Australia
- BAS: Natural environment Research Council NERC-BAS United Kingdom
- UPMC : Université Pierre et Marie Curie France, associated to the MNHN (Museum National d'Histoire Naturelle)
- IMR: Institute of Marine Research (Havforskningsinstituttet) Norway
- UA: University of St Andrew, United Kingdom

2. Agenda and participants

<u>Wednesday 7th June</u>

Working progress during 1st Year of the project and planning for the 2nd year

9:00 Review on project organisation (deliverable deadlines, postdocs, budget …)

Adoption of the meeting agenda – CLS

Progress and planning in Standardisation of acoustic processing for MESOPP datasets

10:00 Antarctic Circumnavigation Expedition (ACE) – Data Collected - USTAN

10:20 Reference Indian Ocean Acoustic Dataset - CSIRO

10:40 Reference Atlantic Ocean Acoustic Dataset - BAS

11:00 Reference Indian Ocean Acoustic Dataset - UPMC

11:20 General discussion: Planning year 2

Progress and planning in micronekton biomass modelling

14:00 Progress in Size-based Model - UTAS

14:30 Atlantis Ecosystem Model Update - UTAS

15:00 Progress in Seapodym-MTL Modelling CLS - UPMC

15:30 Progress in Acoustic Observation Model – USTAN

16:00 Adding One Observation Parameter in Seapodym for Acoustic Biomass Optimisation – CLS – UPMC

16:30 General discussion: Planning year 2

17:00 Publications (ICES special issue, …)

<u>Thursday 8th June</u>

User Requirements for a Central Information System (CIS) on the Acoustic-Based Observations Modelling System

9:00 What is a CIS? Preliminary design for MESOPP CIS – CLS

What should we have in the MESOPP CIS?

Metadata for acoustic and model datasets

Standard Formats

How to compare species or groups between models and acoustic observations?

14:00 Mike St John's seminar on Mesopelagic Micronekton

16:00 Mesopelagic Atlas

16:30 How to link to upper trophic level users? Presentation of EO4Wildlife

<u>Friday 9th June</u>

Open Day

Introduction

9:00 Patrick Lehodey: MESOPP introduction & summary of previous day discussions

Szilvia Nemeth: EU international cooperation with Australia and the Pacific region

Session 1: Acoustic and Micronekton

9:30 Paul Fernandes: Target strengths of two abundant mesopelagic fish species

Anna Conchon: Testing best sampling design of acoustic data for a micronekton model

Cédric Cotté: Structuring effect of the physical environment on trophic interactions

Roland Proud: Modelisation of potential habitats of the main mesopelagics fish according to environmental parameters

Session 2: Micronekton and Predators

10:45 Cédric Cotté: Structuring effect of the physical environment on trophic interactions

Mike Fedak: Very southern elephant seals

Lars Boehme: MEOP

14:00 Laurianne Massardier-Galatà: Use of simulated micronekton in Marin Central Place Forager Simulator (MarCPFS) to explore the future of Kerguelen Antarctic fur seal

Mark Johnson: Using echolocation to study mesopelagic predator-prey interactions

Mike Heath: Modelling food web impacts of pelagic fisheries in a changing Arctic

Patrick Lehodey: Modelling spatially-explicit fish population dynamics with micronekton

Pauline Goulet: Measurements of prey field from a seal's perspective: development of an animal borne sonar tag

16:00 Open Discussion

17:00 Closure of the meeting

3. Introduction

The primary objective of MESOPP is to demonstrate the interest of establishing a common methodology and a connected network of databases of acoustic data for the estimation of micronekton biomass and validation of ocean ecosystem models. The first workshop of the project focused on the standardisation of acoustic data for micronekton modelling. This second workshop has a special focus on the development of the database and e-infrastructure. It was held at the University of St Andrews, Scotland, UK, 7-9 June 2017. The meeting was organized locally by the MESOPP partners Drs A. Brierley and R. Proud.

MESOPP is organized around three themes: acoustic data, models and use cases. It is proposed to deliver three standardized reference datasets of 38 kHz acoustic data in three different regions of the Southern Ocean (South Indian; South Pacific and South Atlantic). They need to be processed with a common methodology to facilitate their use in the modelling and the estimation of biomass and potential changes associated to climate change projections. Finally, model outputs and acoustic databases will be made available for inter-comparison and further analyses of behavior and distribution of large marine species.

The first day of this second workshop was devoted to the review of work progress since the kick-off meeting in Sep 2016, and the planning for the 2nd year. The second day focused on the design of the MESOPP Central Information System (CIS), one of the milestones of the project planned to be released in Nov 2017. Finally, the third and last day was organized as an open science day with a series of presentations and discussions by both partners of the project and invited colleagues. The list of participants is provided in appendix. This report provides a summary of the meeting outcomes.

4. Project administrative and technical issues

After the opening of the MESOPP meeting by Andrew Brierley and Patrick Lehodey, the agenda was adopted with minor modifications on the schedule and Beatriz Calmettes presented a review on the project organization.

4.1. Project deliverables

All deliverables due to this date have been submitted.

Due to delay in postdoc recruitment by UTAS and CSIRO, several deliverables need to be postponed:

- D4.1 Documentation of the models, approaches for standardisation and protocols to be used for model inter-comparisons, should be postponed to end of July 2017 (instead of May)
- D4.2 Methods to downscale model states to replicate acoustic signals in model validation should be postponed to 31/07/2018 (instead of 30/11/2017)
- D4.3 Methods to aggregate acoustic data from vessels of opportunity for use in model validation should be postponed to 31/11/2018 (instead of 30/11/2017)

Therefore, it is necessary to ask for an amendment of the grant agreement. The revised list of project deliverables with partner leading the deliverable is provided in Appendix 1.

The next deliverables are due for Nov 2017. They are the release of the release of web site with e-infrastructure (catalogue and data access services; D2.5: CLS PU), the reference datasets of 38 kHz acoustic backscatter for the three regions (D3.2: BAS; D3.3: UPMC; D3.4: CSIRO) with the collocated NASC and oceanographic variables (D3.5: UPMC).

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4.2. Postdocs / short-term contracts

Roland Proud contract will finish end of March 2018. He will be visiting Rudy Kloser in CSIRO to work on deliverables D4.2 and D4.3.

Anna Conchon contract is finishing end of April 2018. She is working on deliverables D3.6 and D4.4. She will embark onboard the R.V Marion Dufresne in Jan/Feb 2018 with the UPMC research cruise to collect acoustic data with the EK80. There will be trawl survey associated to acoustic in the Kerguelen region.

Alejandro Ariza has been recruited by the BAS to work on the acoustic dataset.

A postdoc position is advertised by UTas. Roland could apply to the position open by CSIRO at the end of his contract with UA.

4.3. Interim report

Beatriz presented the planning to prepare the interim report of the project, due in Jan 2018. It includes a technical and financial part. The reporting function is activated at the end of the reporting period (web access open): 1st of December 2017. All partners must fill their own financial statement, in euros[1], electronically sign it and submit to the coordinator. The dead line is end of January 2018. Only the user with role "Project Financial Signatory (PFSIGN)" can sign and submit so it is important to check that this person will be there to sign. The coordinator reviews all the interim report (technical and financial) and submit to the Commission all parts of the report together. The coordinator may submit the report without financial statements from a partner delaying too long the process. That beneficiary's cost will be considered 'zero' for this reporting period. The commission has 45 days to validate. If accepted payment in the following 90 days. The maximum eligible cost is 45%.

The technical report includes a Part A automatically generated from existing information on the web and new ones that is submitted on the web, eg list of communications, articles etc… The part B is the narrative section. It is required that each partner send its contribution to the coordinator. The text is free and should contain explanations of the work carried out by each partner with an overview of the progress towards the project objectives.

4.4. Communication

A series of newsletters have been published on the MESOPP web site.

Date	Who	Title
Sep. 2016	Patrick	MESOPP project officially started in Hobart
Oct. 2016	Anna	SEAPODYM-MTL, modeling the ocean micronekton biomass
Dec. 2016	Andrew C.	Creation of the largest marine natural reserve, close to Antarctica
Jan. 2017	Sophie	MESOPP on a cruise
Jan. 2017	Anna	THEMISTO campaign aboard the Marion Dufresne
Feb. 2017	Roland	MESOPP in the Antarctic Circumpolar Expedition
Mar. 2017	Beth/Jess	Atlantis ecosystem model for East Antarctica
Mar. 2017	Patrick	Complementarities of GREENUP and MESOPP projects
May 2017	Rowan	Multispecies size spectra models for East Antarctica

[1] Procedure for calculating the rate are on the ECB website: http://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/index.en.html. Select the currency on the chart icon for the currency. Choose the 'HTML5 version' which appears under the name of the currency in the top-left corner. Insert the starting date (01/06/2016) of the reporting period in the field 'from' and the end date (30/11/2017) of the reporting period in the field 'to'. The average for the period will appear above the chart.

Date	Who	Title
May 2017	Rudy	Investigation of deep-scattering layers with a profiling lagrangian acoustic optical system

A list of propositions for coming months was discussed:

- Beatriz/Patrick: MESOPP 2nd workshop
- Cedric: Carbon flux and Mobydick cruise
- Sophie: Next cruise onboard RRS James Clark Ross in South Georgia
- Andrew Brierley: A story on Penguins
- Nils Olav: New acoustic devices
- Lauriane Massardier: modeling Seals with IBM and mesopelagic micronekton model outputs
- Philippe Koubbi: Plankton recorder
- Ask Christophe Guinet for a story on Elephant Seals
- Antarctic Krill (Sophie?)
- Patagonian toothfish (Cedric? Philippe? Andrew?)

It was recognised that there is a need to be more proactive on communication and outreach. A facebook account for MESOPP will be created and media releases concerning MESOPP topics will be published in the outreach page of the web site. It is proposed to make a project poster that can be used by everyone during conferences. Video could be produced for the website as well as animations from model outputs and animal tracks.

Conferences and meetings of interest:

- The Copernicus Marine Week, September 25-29 2017, Brussel, Belgium.
- MEASO18. Marine Ecosystem Assessment of the Southern Ocean, 9-13 April 2018, Hobart, Australia.
- The Effects of Climate Change on the World's Oceans, PICES June 4-8, Washington DC, USA
- ICES 24-27 Annual Science Conference, September 2018, Hamburg, Germany

4.5. Third workshop

A previous proposition was to hold the last MESOPP workshop in Davos Switzerland back to back with the SCAR Conference in June 2018. However, this proposition was revisited because the period is busy for many partners, and the cost of the workshop in Davos could be very high. The initial idea to have the workshop in USA to attract more international collaboration was finally reconsidered. A date in the second half of 2018 would be more convenient for many partners. Therefore, contacts will be researched to organise the third workshop in USA between Sep 2018 and Feb 2019.

4.6. Amendment

The various changes listed during the review of the project require to open a request for amendment to the Grant Agreement. In addition to changes in deliverable deadlines, it will include the change in organization of this second workshop (transfer to partner UA).

5. Working progress during 1st Year of the project and planning year 2

5.1. Progress and planning in standardization of acoustic processing

Several presentations dealing on the progress of activities linked to production of reference acoustic datasets and standardization of acoustic processing and format were presented by MESOPP partners. UA (R. Proud) first gave an overview of the Antarctic Circumpolar Expedition to which he participated (Figure 1). It is the first expedition of the recently created Swiss Polar Institute SPI (http://polar.epfl.ch/). Acoustic data at 12 and 200 kHz have been collected all along the cruise track and these data will become available with a link to the database (~100Gb) on the server. Roland noted that arriving on the continental shelf, DSLs seemed to fade to be substituted on rare occasions by dense aggregations of fish (may be mostly in larval and juvenile stage) and krill, in contrast to what was observed by Letessier et al (2016) in tropical region.

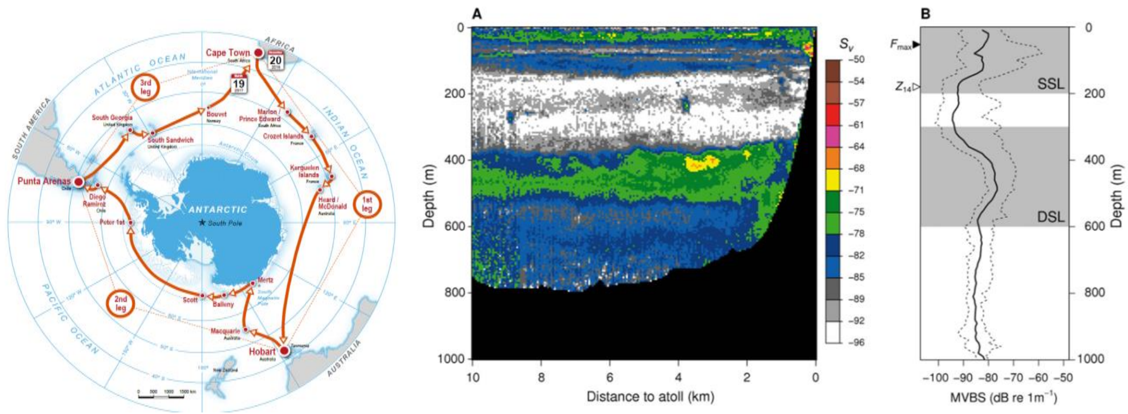

Figure 1: Track of the Polar Expedition Cruise and echogram from Letessier et al (2016)

CSIRO (R. Kloser) provided an update on IMOS (Indian/Pacific) dataset. Since July 2010, 137 transects from 17 vessels covering 310,634 km have been processed and available on-line (http://imos.org.au/). A study (paper) is ongoing to review the biomass of mesopelagic fish (lanterfish) in Tasman Sea based on acoustic data and net trawling data. It will provide a very useful ground-truth estimate of biomass to be used for calibrating models. Relative biomass index indicates consistently higher biomass in the western part of Tasman Sea relatively to the eastern part. A new promising acoustic profiler is currently developed at CSIRO (cf MESOPP newsletter). Transects included in the MESOPP reference data set still needs to be defined. However, they are all available already on the IMOS website. They will have to be checked for the format and resolution standard defined for MESOPP.

Figure 2: Map giving average biomass estimates of lanternfish (Sutton et al., in prep), and picture of CSIRO acoustic profiler.

Sophie Fielding (BAS) introduced Alejandro Ariza who has been recruited with the MESOPP project to work on acoustic data collected by the BAS. They presented the progress on the reference Atlantic Ocean acoustic dataset with the acoustic routines and quality checking methods developed. They use the dataview software developed by CSIRO and some home-made algorithms to extract data.

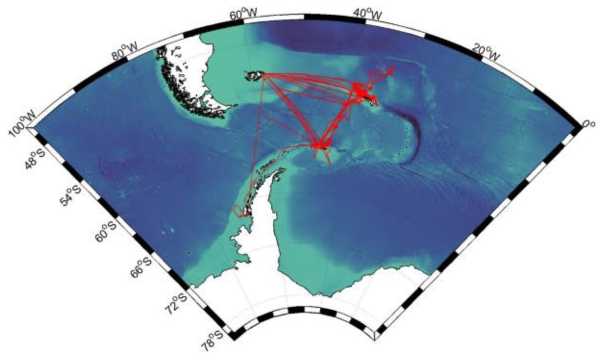

Figure 3: BAS acoustic transits. One transit is defined by a maximum of 12h with speed > 4knts.

The 90% percentile of signal is used to qualify the data. This approach removes less data than the IMOS approach (using white signal between pings). The bottom topography is defined from GEBCO dataset and sound speed is computed using temperature climatological (CAR) data.

BAS proposes to use a target strength average value to estimate the range detection limit. The value -80 db used by Irigoien et al. (2014) is first suggested but this value is seen as too high and the group would recommend - 40 db.

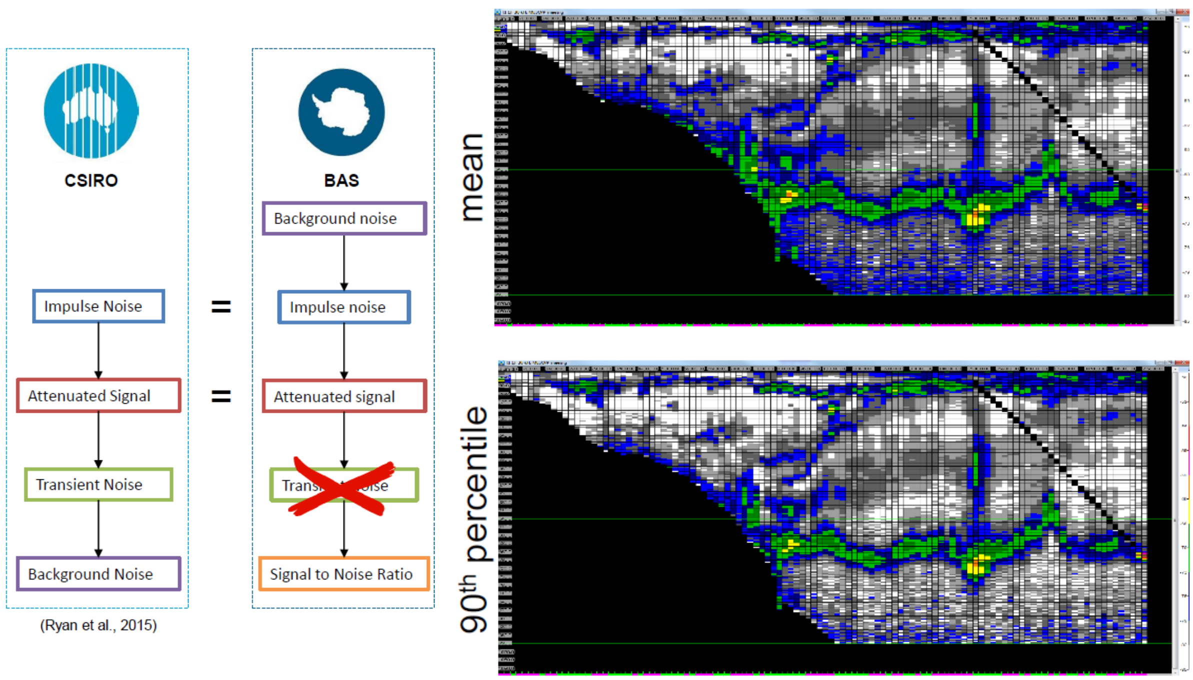

Figure 4 - Difference in CSIRO and BAS processing chains of acoustic data and use of the 90% percentile of signal to qualify the data.

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Cedric (UPMC/MNHN) presented the various research projects and cruises organized onboard the R.V. M Dufresne II. The Mycto3D project allowed to collect acoustic data over 3 summer and 2 winter seasons (EK60: 38 and 150 KHz) between La Reunion Island and Kerguelen. Then EK80 replaced EK60 and the cruise for Themisto project collected several frequencies (18 38 70 120 200). Currently the SOCLIM project is ongoing until 2018 and will be followed by Mobydick research cruise.

It was noted that datasets for the project should stop in 2017 (starting in 2013). The resolution selected is 1km (horizontal) x 10m (vertical).

The issue of data storage has been discussed. The European AtlantOS project has a working group on Acoustic (chaired by Nils Olav) but these acoustic data are for commercial target species estimate. Acoustic data for micronekton could be another variable. This needs to be investigated.

Anna presented examples of collocated NASC and oceanographic variables (oceanographic stations OISO). This is key information to develop detection algorithms of vertical layers used in modeling and it was agreed that availability of these collocated dataset through the MESOPP website should be very useful.

Anna plans to visit Sophie & Alejandro in BAS to process RV Marion Dufresne acoustic data and could embark for the Mobydick cruise in 2018.

Then discussion considered the definition of several test datasets with different processing of noise with the objective of quantifying the sensitivity of processing methods to the biomass estimate and ecosystem model validation.

5.2. Progress and planning in micronekton biomass modelling

MIZER (Size-based) model

Rowan presented an update of his work on the development of the size-based model (MIZER) for the Kerguelen Axis (Figure 5). The modeling is closely linked to the observations collected during a research cruise in this area in the first quarter of 2016. From this cruise and previous ones, 12 groups of zooplankton, 23 groups of micronektonic fishes and squids, and 25 groups of micronecton predators have been identified. The modeling approach requires various parameters by group of species /taxa. Some are derived from the data collected, some others are not easy to estimate or to derive from the literature.

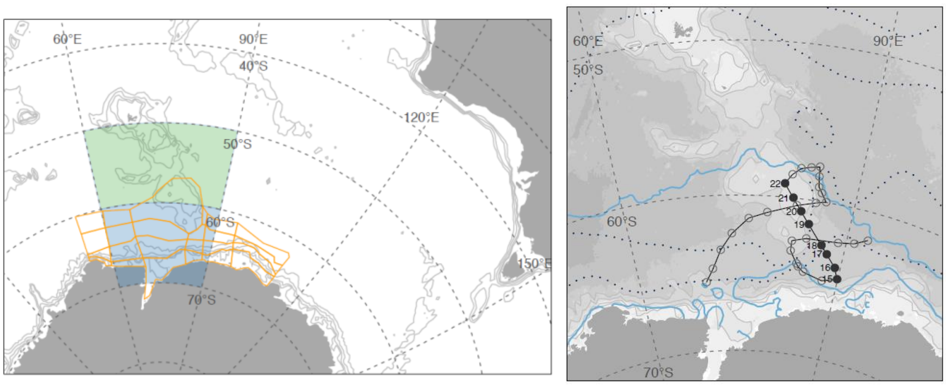


Figure 5: The Kerguelen axis domain for MIZER model and positions of the stations during the Research cruise (Jan-Mar 2016).

Atlantis

Progress on the third model Atlantis was given by Rowan in the name of Beth and Jess. Currently most of the work is devoted to definition of functional groups and parameterization/calibration, especially for the diet matrix (Table 1). The physical forcing is provided by a Circumpolar configuration of the ROMS model at resolution ¼° for a climatology over the period 1992-2008. The other inputs are biological parameters, the diet matrix and initial conditions for all functional groups. The model includes 3 groups for the benthos, 3 groups at the mid-trophic level (krill, pelagic and mesopelagic fish) and one additional group for salps and 20 high trophic level species described with size-age structures. The model is still in is phase of calibration.

Table 1: List of functional groups defined for Atlantis in the Antarctic/Kerguelen Axis.

Pelagic Bacteria	Biomass pool	Toothfish	Size/age structured
Sediment bacteria	Biomass pool	Icefish	Size/age structured
Ice Bacteria	Biomass pool	Cephalopods	Size/age structured
Detritus	Biomass pool	Antarctic Fur Seal	Size/age structured
Ice Diatoms	Biomass pool	Elephant Seal	Size/age structured
Ice Mixotrophs	Biomass pool	Crabeater Seal	Size/age structured
Coccolithophores	Biomass pool	Leopard Seal	Size/age structured
Pelagic Picophytoplankton	Biomass pool	Other Seal	Size/age structured
Pelagic Diatoms	Biomass pool	Adelie Penguin	Size/age structured
Pelagic Dinoflagellates	Biomass pool	Emperor Penguin	Size/age structured
Ice Zoobiota	Biomass pool	Other Penguins	Size/age structured
Microzooplankton	Biomass pool	Albatross	Size/age structured
Mesozooplankton	Biomass pool	Skuas	Size/age structured
Macrozooplankton	Biomass pool	Other Seabirds	Size/age structured
Salps	Biomass pool	Minke Whales	Size/age structured
Benthic Deposit feeders	Biomass pool	Other Baleen Whales	Size/age structured
Macrobenthos	Biomass pool	Orca A	Size/age structured
Benthic Filter feeders	Biomass pool	Orca B	Size/age structured
Krill	Size/age structured	Orca C	Size/age structured
Fish Pelagic	Size/age structured	Sperm Whales	Size/age structured
Fish Mesopelagic	Size/age structured	Carrion	Biomass pool

SEAPODYM

Anna and Patrick presented recent developments with SEAPODYM. A good progress was achieved in the optimization of the zooplankton functional group based on two sets of observations: a climatological distribution of zooplankton biomass at global scale (database COPEPOD) and various results from laboratory experiments providing the time of development of zooplankton species in relation to water temperature. Since the model includes a Maximum Likelihood Estimation approach for the parameters, it was possible to demonstrate that a better fit to zooplankton data can be achieved using the VGPM-EPPLEY product (Figure 6). The new model simulation outputs will be made available on the MESOPP web site with the micronekton outputs (Figure 7). A major issue for these simulations is the uncertainty on the primary production derived from satellite ocean color data, since there are large data gaps especially in winter from autumn to early spring season. Results will be presented in July at the SCAR conference in Leuven (Belgium).

For the micronekton, the parameterization of energy transfer from the primary production to the functional groups based on a compilation of data in the literature (Lehodey et al., 2010) is still used. However, the optimization approach is developed to use acoustic data (Lehodey et al 2015). For practical reason the optimization method has been developed assuming that the acoustic signal was fully proportional to the biomass of micronekton (the state variable of the model). However, it is now necessary to account for variable response of organisms to the acoustic signal. It is proposed to run optimization experiments in different eco-regions, assuming that they are defined with homogeneous communities of species and thus homogeneous acoustic responses. Therefore, optimization experiments are conducted separately in different eco-regions defined by climatological fronts in the Southern Ocean for which there are sufficient observations (Figure 8). They show that the subtropical eco-region is clearly distinct from the others, with higher acoustic ratios in the deepest layer during the day. The three others are more homogeneous with similar patterns in energy allocation to functional groups.

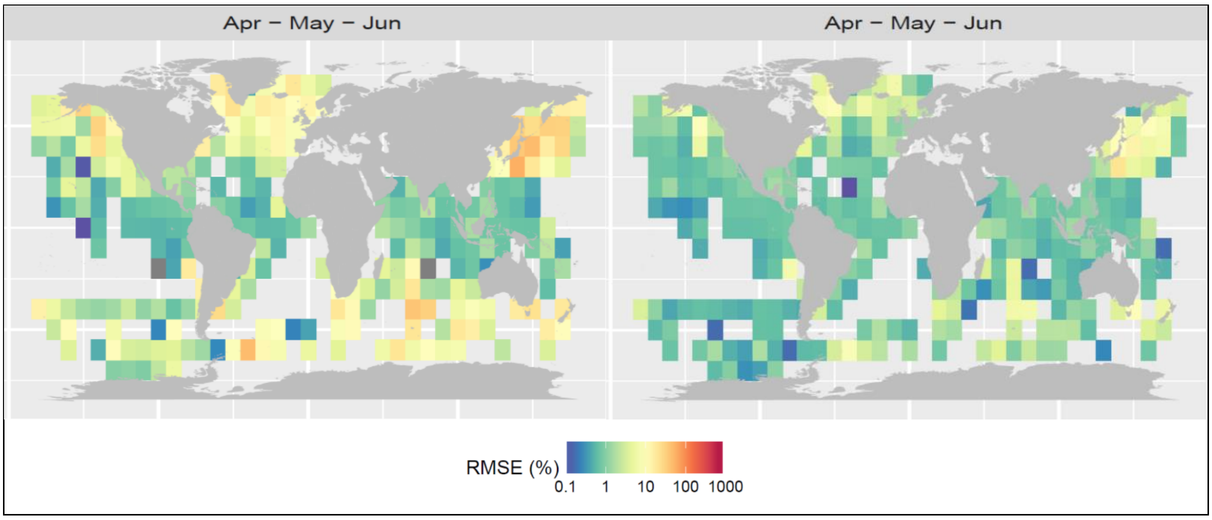


Figure 6: Maps of Relative Root Mean Square Error of biomass (RMSE) for the 2nd quarter (climatology) for the zooplankton predicted with NPP computed using (left) VGPM or (right) VGPM-EPPLEY.

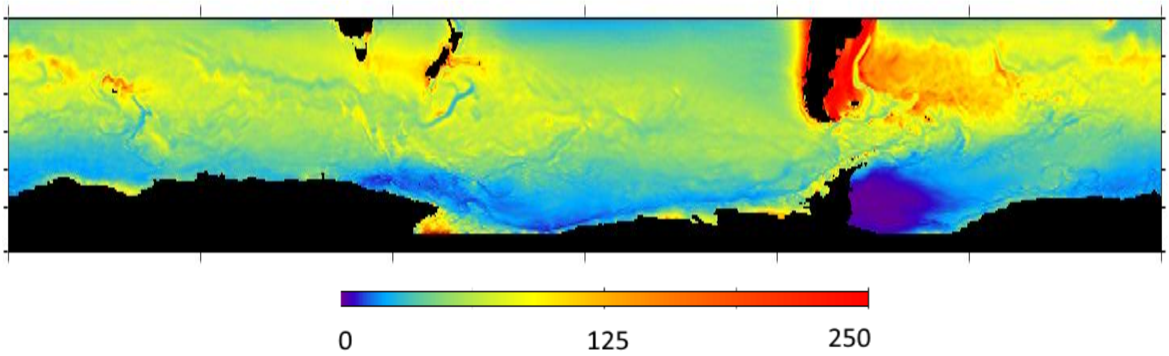


Figure 7: Average biomass (g m^{-2}) of zooplankton (2006—2015) predicted with SEAPODYM

It was noted that AAD is also developing an ECOPATH application to the Kerguelen axis region that could be included in MESOPP for the comparative analysis of models.

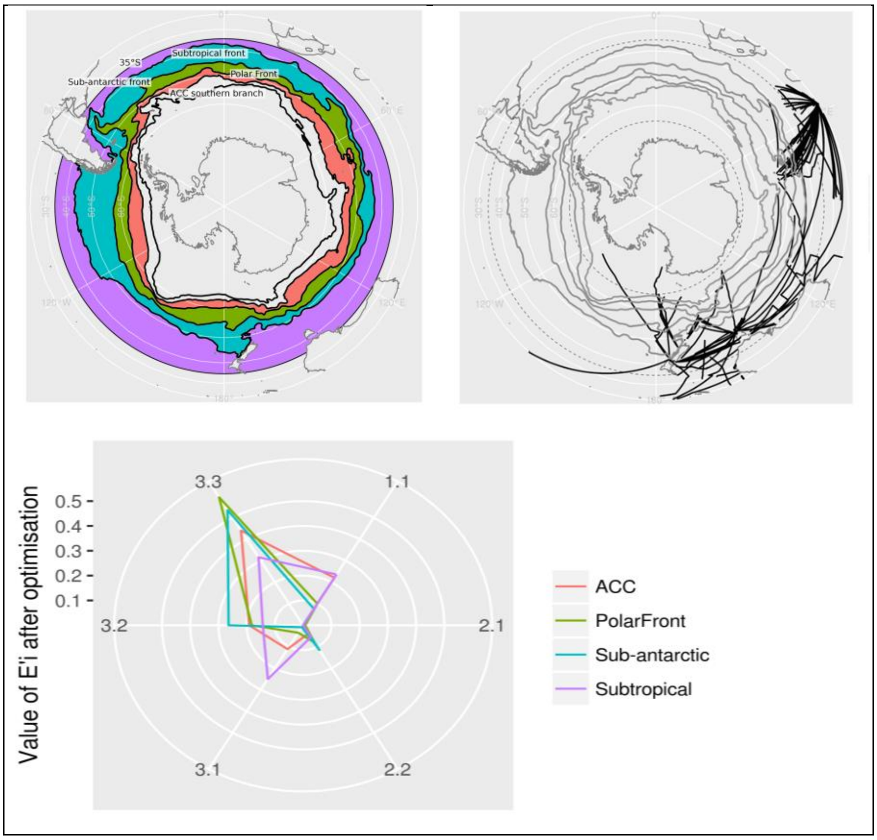


Figure 8: Parameter optimization by eco-region. The energy tranfer coefficients are estimated in each eco-region from available acoustic data (top right) and compared (bottom).

Acoustic observation modeling

The complementary approach to the model parameter estimates by eco-region above is the development of acoustic observation biomass to provide direct acoustic biomass estimate based in these regions. Roland Proud reviewed the different processing steps needed to achieve this objective. A few models already exist, e.g., for krill (McGehee et al. 1998) or myctophids with swimbladder (Scoulding et al 2015).

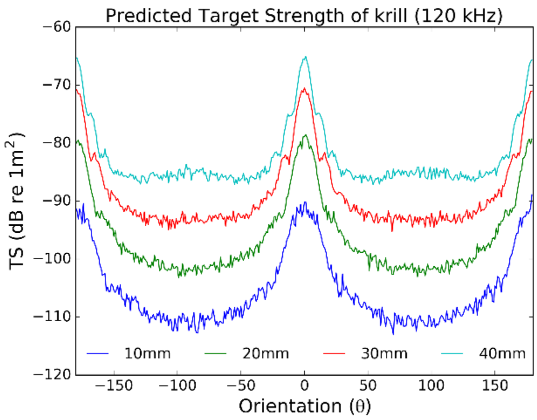


Figure 9: Acoustic observation model for krill (120 kHz) from McGehee et al (1998).

A classification of the different groups of organisms is proposed based on their acoustic characteristics and thus requiring different acoustic observation models (Figure 10). The acoustic response is driven by anatomy, orientation, size and density. It would be useful to build a species catalogue with characteristics needed for acoustic observation models, e.g., the following variables:

- Species name/other taxonomic rank (e.g. Family: Myctophidae)
- Environmental ranges (temperature, salinity, oxygen content etc.)
- Migration descriptors
- Distribution of existing records (e.g., from OBIS database, and Atlas of mesopelagic fish)
- Anatomy (swimbladder, size range, body density)
- Aggregation type (layer, swarm etc)
- Aggregation dimensions
- Frequency response
- Most appropriate scattering model
- Model parameters
- Diel/Seasonal behaviour (location, depth etc.)
- Confidence and quality control metrics

In some case it may be needed to develop individual-based model (IBM) to differentiate signal according to the behavior of species (orientation during vertical migration, aggregation). This approach should help to produce the most accurate biomass estimate in key sampling stations and extrapolation to regions with backscatter dominated by similar species/groups.

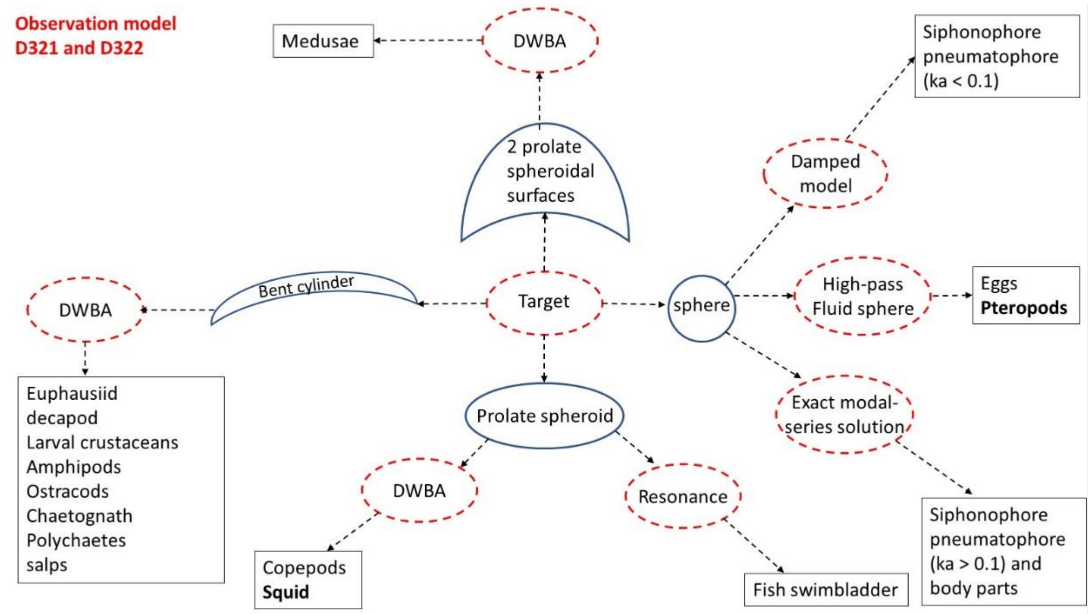


Figure 10: Classification of acoustic observation models according to species characteristics

The first day of the meeting finished with a discussion on the publication planning for the project. There is a special issue proposed in ICES journal on “Mesopelagic resources – potential and risks” to which several partners envisage to submit an article.

6. Central Information System (2nd meeting day)

6.1. Acoustic data

The 2nd day of the workshop was devoted to the design of the Central Information System (CIS). A general presentation gave an overview on what should be expected from a CIS. It should offer a single entry point and standardized interfaces to access information and data. Through the CIS a user can obtain general information, browse the catalogue of data to select the products, get information on the products and access to the products (Figure 11).

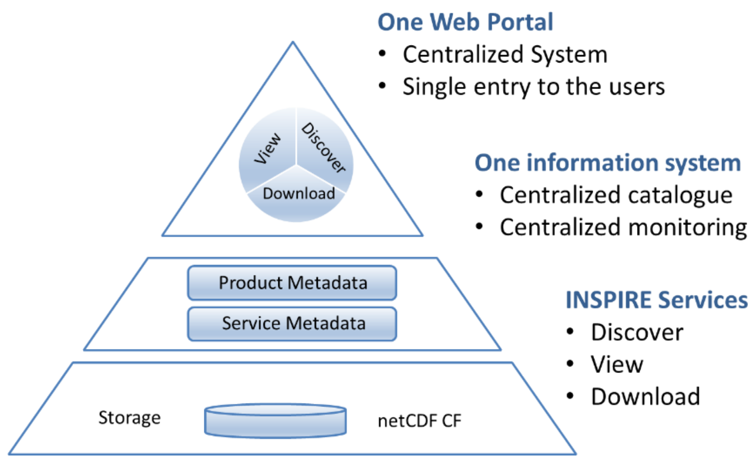


Figure 11: Structure of the MESOPP CIS.

The products available through the MESOPP portal are the acoustic products: Transects, mooring, profiles (3 datasets from IMOS, SONA, UPMC), the micronekton products (simulated from Seapodym, Atlantis, and Size-based models) and the physical and biogeochemical products if they have been pre-processed to be used in the models and are not available from another original source.

Beatriz presented a mock-up of the system pre-designed by CLS. The MESOPP web site will have a special page to access to the data catalogue with map and date tools to select the data. Data can be also selected through a series of filters (acoustic, frequency, model etc…). Each type of data set is described in detail and illustrated. Once selected it can be accessed in a ftp directory. While data are public, a user registration is implemented to follow the use of data and inform the list of users of changes and new products.

Then the discussion moved to data format. All data will be in NetCDF, CF compliant format (http://cfconventions.org). Note that since the CIS is a demonstrator, it cannot have all the functionalities of a real one, so that figures illustrating datasets will be pre-generated (png format). Similarly, there will be no interconnected databases and all datasets need to be provided to be stored on the MESOPP server in CLS. The format of acoustic data will be defined starting from the document established by the CES WGFAST group and the IMOS manual. However, a few inconsistencies with the NetCDF standard were noted and a list of questions and suggestions was prepared to be submitted to the ICES group to keep a common format.

It is proposed to make a script allowing to test the compliance of submitted files to the approved format. The script (python) should be made available on the MESOPP web site.

Finally, the CIS will also include a special dataset with collocated profiles of acoustic and environmental variables (temperature, salinity, oxygen, fluorescence, …) collected during the OISO French research cruises onboard the RV Marion Dufresne. Other partners are encouraged to feed this dataset from other regions since they are critical information to develop and improve models.

All data need to be provided to CLS one month before the deadline (1St Dec).

6.2. Model outputs

Though the objective of MESOPP is the processing and distribution of acoustic standard data, it is proposed to include an access to model outputs in the CIS. Each model has its own metadata and format (regular lat/lon grid format for Seapodym; polygons for Atlantis; and geographical boxes for the size-Based model). They need to be provided by the developers to design the CIS infrastructure. The three models have different variables as well. A concordance matrix for the mesopelagic groups is needed to help in the inter-comparison analysis. Model predicted data will be also provided in NetCDF format.

In the afternoon, the group discussed what could be the future developments of the CIS after this first release. Metrics and diagnostics need to be defined to facilitate evaluation of models and inter-comparison. Examples have been provided for SEAPODYM outputs (Figure 6). It is noted that before absolute calibration of biomass, essential information is already provided by the seasonal and interannual variability. Seasonal signal in the Southern Ocean is particularly well marked and thus should be a first criterion to meet in model evaluation. However, given the longer life span of species living in cold waters, the interannual variability could be also a clear and strong signal in the acoustic and mesopelagic biomass useful to validate model outputs. A link with the Biogeographic Atlas of the Southern Ocean initiative (update of this Atlas being a deliverable of MESOPP) would be also interesting, especially to assist in the definition of ecoregions.

Finally, case studies with predators of mesopelagic species can be a valid indirect evaluation of both acoustic observation models and micronekton and ecosystem models. Large predator species in the Southern Ocean (seals, whales, penguins, albatrosses) are amongst those that beneficiate of a large research effort using satellite tracking systems. The European project EO4 wildlife was presented. It is a platform for wildlife monitoring integrating Copernicus and ARGOS data. The objectives are to design a system to access Sentinel Earth Observation (EO) data, ARGOS databases of archive and real time, thematic databank portals; to provide an operational easy-to-use platform to query, search, mine and extract information from these different databases, and to develop and run algorithms for dedicated data analytics, models and data visualization. A synergistic approach in the development of both MESOPP and EO4wildlife web platforms would be beneficial to both projects. The first one benefit of predator databases and analyzing tools, and the second would access to simulated prey distributions. The project PI will be contacted.

7. MESOPP Science Open Day

The third day of the meeting was devoted to a series of presentations by partners and invited colleagues interested in MESOPP activities and products. After a short introduction and summary of previous day discussions, P. Lehodey introduced the MESOPP project Officer Szilvia Nemeth who gave an overview of EU objectives and opportunities regarding international cooperation, and especially with Australia and the Pacific region. She encouraged MESOPP to develop further collaborations with other colleagues in USA, New-Zealand and other Pacific Countries.

The following first session was devoted to acoustic and micronekton. Paul Fernandes from the University of Aberdeen, UK, presented results on the measure of target strength of two abundant mesopelagic fishes in the northeast Atlantic Ocean: *Benthosema glaciale,* Myctophidae and *Maurolicus muelleri,* Sternoptychidae. The acoustic backscattering characteristics for these two species is analysed using swimbladder morphology derived from digitized soft x-ray images, and empirical (in situ) measurements of target strength (TS) in the Norwegian Sea. A backscattering model based on a gas-filled prolate spheroid was used to predict the theoretical TS for both species across a frequency range between 0 and 250 kHz. TS is sensitive to the viscosity, swimbladder volume ratio, and tilt. Theoretical TS predictions close to the resonance frequency were in good agreement (±2 dB) with mean in situ TS derived from the areas acoustically surveyed that were spatially and temporally consistent with the trawl information for both species (see Scoulding et al 2015).

Mean TS measurements for two abundant mesopelagic fishes (Scoulding et al 2015)

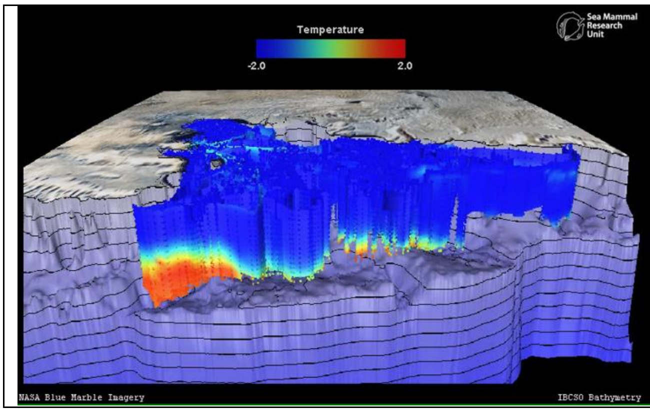

Pearlside - *Maurolicus muelleri* (Sternoptychidae)


Northern lanternfish - *Benthosema glaciale* (Myctophidae)

	18 kHz	38 kHz	120 kHz	200 kHz
M. muelleri	-53.61 (204)	-60.83 (190)	-62.93 (229)	-66.35 (26
B. glaciale	-54.17 (216)	-62.13 (111)	-65.63 (81)	-67.51 (5

The following presentation by Anna Conchon gave preliminary results on simulations used to estimate optimal acoustic sampling network. The study is co-funded with a task in the H2020 AtlantOS project. Observing System Simulation Experiments are classical approaches to test the best design of sampling effort. Here, the model SEAPODYM-LMTL is used to create pseudo-observations with a given set of model parameter values. These values are changed before to run optimisation experiments using different sampling network of pseudo data allowing to identify which one provide the best results to retrieve the original parameterization. More simulations are conducted after introducing noise in the forcing and finally in the observation to mimic a more realistic observation and modeling framework. Preliminary results suggest easier estimation of parameter values in less dynamic physical environment.

The second session focused on interactions between micronekton and predators. Mike Fedak from the University of St Andrews gave an overview of the work conducted by the Sea Mammal Research Unit (SMRU) to understand the physical changes in water temperature in the Amundsen Sea using instrumented animals (seals and elephant seals). There is a strong interest to use these animals. There is low wage costs; they cover sampling during winter months; they are not impeded by ice cover and they provide large spatial coverage. In ~200 days, seals provided over 11,000 profiles over an area roughly 20,000 km^2.

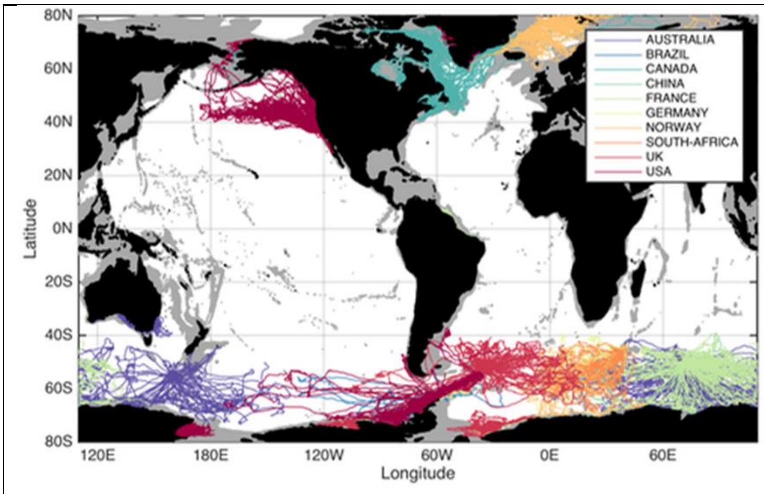


Where the seals find the “warm” water, from M. Fedak.
Ocean2ice objective: learn how and why “warm” ocean water gets close to the ice.
http://www.istar.ac.uk/
P.I. Professor Karen Heywood, University of East Anglia.

FORM-NT-GB-

Of course, in the same time these tracking data provide very useful detailed information on their feeding ecology and foraging behavior. For instance, Ellies and Weddells seals fed in geographically overlapping places but used somewhat different aspects of the topography and water column, and both species are equally capable of foraging in heavy ice cover. Weddell seals avoid open water and female Ellies are uniquely capable of exploiting the pelagic realm because they don't haul out for up to 7 months.

The project MEOP (Marine Mammals Exploring the Oceans Pole to Pole**)** was presented by Lars Boehme (Univ. St Andrews). This consortium was created to support the International Polar Year in 2007-08 to federate several national programs investigating the behaviour and well-being of marine animals, while focusing on the provision of oceanographic data from animal-borne instruments. Ten Countries are involved and the program is still alive and has produced 103 publications. Currently, MEOP has collected more than 510,000 profiles from nearly 1,200 tags (figure) contributing to ~98% of temperature and salinity data from the SO pack ice, allowing to improve significantly the quality of the projections provided by ocean-climate models. There is a clear interest to confront this database of animal tracking with their prey distributions simulated by MESOPP models.

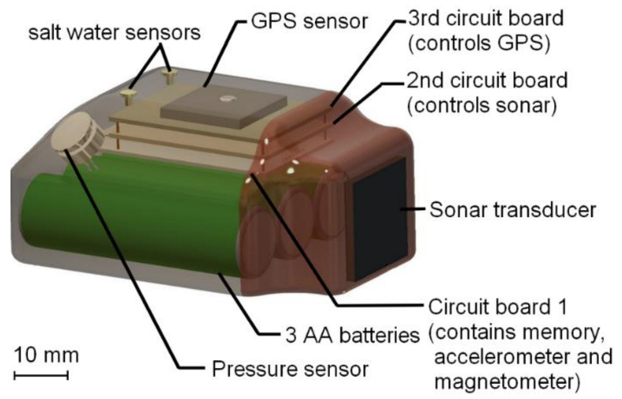


MEOP database (Kindly from Lars Boheme)

Roland Proud presented one approach to model potential habitats of the main mesopelagic fish according to environmental parameters. It is based on an eco-definition of regions defined using clustering approach and a series of environmental drivers. In a previous analysis (Proud et al 2017) it was shown that primary production and temperature at depth of the DSL (Deep Scattering Layer) are good proxy of mesopelagic biomass. Other identified key variables for the SO are bathymetry and Sea Ice extent.

The following presentation by Mark Johnson (SMRU; St Andrews) focused on the interactions between mesopelagic prey and predators (toothed whales) using echolocation recorders. Changes in click numbers by the predator are correlated to hunting behavior allowing to identify where the prey catch occurs, when the echolocation shift from regular click to a buzz period (Tyack et al. 2006). It was shown that prey respond to approaching whales and more than 50% try to escape, with some apparent success in ~35 % of cases. There is also foraging activity on the sea floor (Arranz et al. 2012). Echograms analysis give an estimate of prey escape speeds: typically, 1.5 ms^{-1} with maximum 4 ms^{-1}. From stomach contents analysis, the size of prey is in the range 10-40 cm, so that this speed would correspond to 10 Body Length per second (Wisniewska et al. 2016).

Pauline Goulet pursued on this topic with a presentation of her work dealing with the measurement of prey field from a seal s perspective. Unlike toothed whales, seals don't echolocate. The idea is to use the animal embarked beacon as a sonar to estimate the abundance of prey in the immediate environment of the seal. The study, still in the development and test phase on captive harbour seals. It will be tested at sea with elephant Seals. Miniaturisation is needed for deployment on other taxa (Antarctic fur seals, penguins…).

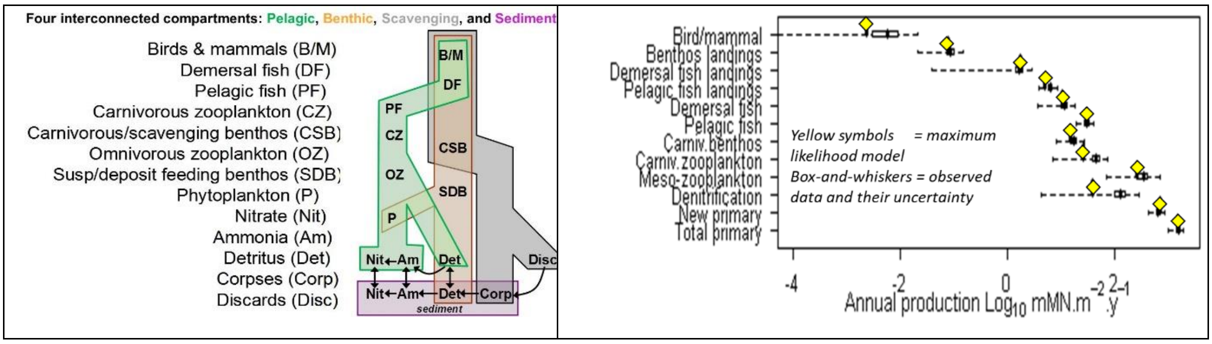


Development of a sonar tag at SMRU, St Andrews.

Cédric Cotté (MNHN, UPMC) presented a study on the structuring effect of the physical environment on prey-predator interactions. The Kerguelen region is used as a case study. It is characterized by a rich ecosystem with a plume of high chlorophyll source leeward of the island and enriched by sources of iron, which is often a limiting factor of the photosynthesis in the deep ocean. Then the drift of maturing waters masses under the influence of currents likely create accumulation of prey that are targeted by predators. Several research cruises are conducted in the area combining physical oceanography, acoustic recording, and biological sampling to describe these processes that can be coupled to animal tracking data.

The last session of the day included a diversity of modeling approaches. The first one by Mike Heath (University of Strathclyde, Glasgow, UK) was to investigate the impacts of pelagic fisheries on the food web in the Barents Sea where rapid changes are observed. The Sea ice extent is declining, the net primary production is increasing and fish communities distributions are shifting. The StrathE2E food web model is used to simulate these changes. It is 1D model driven by physical and chemical environmental variables and fishery harvesting rates. The model estimates flow rates of nitrogen between the living, dead and inorganic components of the system. A computational algorithm is used to search for the maximum likelihood set of 72 parameters given the entire suite of observations available.

StrathE2E application to the Barents Sea



Once parameterized, the model can be used to run various scenarios including change in sea ice extend and different fishery harvesting, including the mesopelagic fish group.

The following presentation by Lauriane Massardier-Galata was on the modelling of the Kerguelen Antarctic fur seal population with an Individual based Model (MarCPFS = Marine Central Place Forager Simulator). It is a spatially explicit bio-energetic simulator that simulate the rearing period of Antarctic fur seal and the the female behavior. The model includes artificial intelligence elements with memorization/learning abilities of the richest resources locations and decisions rules to continue foraging or to return to the island, while it monitors the maternal and pup energy balance. The model is tested first with static false maps of prey distribution at different degrees of aggregation. These first simulations allowed to identify an optimal body length in relation to the distance to the resource (Massardier Galata et al. in press). The second series of simulations is using micronekton fields predicted from SEAPODYM and includes the effect of currents on the animal movement. This more realistic feeding environment includes interannual variability and can explain favorable yeas with high rates in pup survival (≈ 76%). The potential impact of climate change is investigated and suggests a decrease of favorable years with breeding success > 50% associated to an Increase of travel time and time at sea that has a strong impact on survival.

Patrick Lehodey gave the last presentation dealing with the SEAPODYM model component dedicated to the population dynamics of fish. This spatially -explicit representation of fish population dynamics is based on the definition of feeding and spawning habitats that both include micronekton as a key explanatory variable. The feeding habitat is the product of micronekton biomass in epi and mesopelagic vertical layers weighted by accessibility coefficients linked to temperature and oxygen constraints. The spawning habitat use zooplankton as prey of fish larvae but also micronekton as predator of these larvae. So, the successful recruitment of larvae results from the balance between these two mechanisms in addition to the local biomass of adult spawners. The model also includes a Maximum Likelihood Estimation approach to estimate the model parameters (habitat, movement, natural and fishing mortality, recruitment) based on several hundred thousand's spatially redistributed catch and length frequency data. Though it has been initially developed for tuna, mechanisms are sufficiently generic to be adapted to other species.

8. Conclusion of the workshop

This second MESOPP workshop was successful in defining the needs required for the development of standard datasets and their access though the web site (CIS). The ongoing and future activities were reviewed. A few changes in the planning of activities, some delays in postdoc recruitments and new opportunities make necessary to prepare a revision of the grant agreement that will be prepared in the coming weeks. The preparation of milestones (datasets and CIS) is on a good track and should be released in due time. The different approaches of MESOPP partners are converging to propose a method to use acoustic data in models, with the definition of homogeneous ecoregions becoming central. More interactions should be developed with colleagues working on behavioural ecology of large marine animals as they could benefit of acoustic and model biomass estimates, while these large detailed animal tracking datasets could also provide indirect validation of mesopelagic biomass and habitat distributions. The 3rd and last MESOPP workshop is finally planned to be organized in the USA to extend the network of collaborators. Several options will be explored.

9. References

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10. Attachment A

Mesopelagic Southern Ocean Prey and Predators

2nd Workshop: "User Requirements for a Central Information System (CIS) on the acoustic-based observation-modelling system. University of St Andrews, St Andrews, Scotland, United Kingdom, 7-9 June 2017

List of participants

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11. Status of deliverables

	Title	Lead Beneficiary	Status	Due Date
D1.1	Project Management plan	CLS	Subm.	Jul-16
D1.2	Quarterly project progress report including technical and finance period report	CLS	Subm.	Aug-16
D1.4	Dissemination & exploitation plan	CLS	Subm.	Aug-16
D1.5	Dissemination through web site and social networks	CLS	Subm.	Aug-16
D2.4	First release of web site	CLS	Subm.	Aug-16
D2.1	Report on Workshop 1	CSIRO	Subm.	May-17
D4.1	documentation of the models, approaches for standardisation and protocols to be used for model inter-comparisons	UTAS	Subm.	May-17
D2.5	Release of web site with e-infrastructure (catalogue and data access services	CLS	Subm.	Nov-17
D3.2	Reference dataset of 38 kHz acoustic backscatter for South Atlantic sector Southern Ocean	BAS	Subm	Nov-17
D3.3	Reference dataset of 38 kHz acoustic backscatter for South Indian ocean sector	UPMC	Subm	Nov-17
D3.4	Reference dataset of 38 kHz acoustic backscatter for South Pacific Ocean sector	CSIRO	Subm	Nov-17
D3.5	Collocated NASC and oceanographic variables	UPMC	Subm	Nov-17
D3.6	Definition of taxonomic/functional/energetic group in MESOPP models in relation to existing acoustic information	CSIRO	Updated	Feb-18
D2.2	Report on Workshop 2	CLS	Active	May-18
D3.1	Report of acoustic processing routine and quality checking methods	BAS	Active	May-18
D4.7	Modelisation of potential habitats of the main mesopelagic fish according to environmental parameters	USTAN	Active	May-18
D4.8	Characterizing large scale micronekton assemblages based on acoustic data, in situ sampling and oceanic variables	UPMC	Updated	May-18
D4.2	Acoustic observation model linking ecological models to acoustic signals	IMR	Updated	Jul-18
D4.6	Atlas of the main mesopelagic fish in the Southern Ocean	UPMC	Updated	Sep-18
D2.7	Roadmap towards a global integrated observing and modelling system.	CLS	Active	Nov-18

D4.3	Methods to process acoustic data from vessels of opportunity for use in ecosystem model validation	CSIRO	Updated	Nov-18
D4.4	Publication on statistical methods for estimating skill of mesopelagic models to replicate acoustic observations	CLS	Updated	Nov-18
D4.9	Use of micronekton data and models to improve ecology of top predators	USTAN	Active	Nov-18
D3.7	Potential update on the definition of taxonomic/functional/energetic group in MESOPP models in relation to new acoustic technology information	CSIRO	Updated	Feb-19
D2.6	Final release with update of products	CLS	Active	Mar-19
D1.3	Final report	CLS	Active	May-19
D1.6	Dissemination Report	CLS	Active	May-19
D2.3	Report on Workshop 3	CLS	Active	May-19
D4.10	Joint Australian and French reports to CCAMLR	AAD	Active	May-19
D4.5	Report and publication on model inter-comparison, including publication of the methods used in this project	UTAS	Active	May-19

12. List of acronyms

TBC	To be confirmed
TBD	To be defined
AD	Applicable Document
RD	Reference Document
SCAR	Scientific Committee on Antarctic Research (SCAR) is an inter-disciplinary committee of the International Council for Science (ICSU). SCAR is charged with initiating, developing and coordinating high quality international scientific research in the Antarctic region (including the Southern Ocean), and on the role of the Antarctic region in the Earth system.
CCAMLR	The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) was established by international convention in 1982 with the objective of conserving Antarctic marine life. This was in response to increasing commercial interest in Antarctic krill resources, a keystone component of the Antarctic ecosystem and a history of over-exploitation of several other marine resources in the Southern Ocean.
DVM	Diel Vertical Migration or diurnal vertical migration: a typical pattern of daily vertical movement used by many meso- and bathy- pelagic organisms
IWC	The International Whaling Commission is an Inter-governmental Organisation whose purpose is the conservation of whales and the management of whaling. The legal framework of the IWC is the International Convention for the Regulation of Whaling. This Convention was established in 1946.
GOOS	GOOS is a permanent global system for observations, modelling and analysis of marine and ocean variables to support operational ocean services worldwide. GOOS provides accurate descriptions of the present state of the oceans, including living resources; continuous forecasts of the future conditions of the sea for as far ahead as possible, and the basis for forecasts of climate change.
IMBER	Previously known as OCEANS, IMBER was initiated by the IGBP/SCOR Ocean Futures Planning Committee in 2001. The intention was to identify the effects of global change on the ocean and the most important biological and chemical aspects of the ocean's role in global change.
ICED	Integrating Climate and Ecosystem Dynamics in the Southern Ocean http://www.iced.ac.uk/index.htm. ICED is an international multidisciplinary programme launched in response to the increasing need to develop integrated circumpolar analyses of Southern Ocean climate and ecosystem dynamics. It has been developed in conjunction with SCAR, the Scientific Committee on Oceanic Research (SCOR) and the International Geosphere-Biosphere Programme (IGBP), through joint support from the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) and Global Ocean Ecosystem Dynamics (GLOBEC) programmes. The ICED vision is to develop a coordinated circumpolar approach to better understand climate interactions in the Southern Ocean, the implications for ecosystem dynamics, the impacts on biogeochemical cycles, and the development of sustainable management procedures.

