

IsoEcol 2018

11th International Conference on the Applications of
Stable Isotope Techniques to Ecological Studies

WWW.ISOECOL.COM/2018

30 July – 3 August 2018

Universidad Andrés Bello, Viña del Mar, Chile.



Programme and Abstracts



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Dr Maritza Sepúlveda (Universidad de Valparaíso)

Dr Sebastian Klarian (Universidad de Andrés Bello)

Dr Verónica Molina (Universidad de Playa Ancha)



BIENVENIDO A ISOECOL 2018!

On behalf of the conference organising committee, sponsors and supporters, it is our great pleasure and honour to welcome you to Viña del Mar, Chile, to participate in the 11th International Conference on the Applications of Stable Isotope Techniques to Ecological Studies (IsoEcol 2018). This, the first IsoEcol to be held in South America, will take place between 30 July and 3 August 2018 at the Universidad de Andrés Bello. This modern campus is located ca. 1km from the Pacific Ocean and is within walking distance of most hotels in the small city of Viña del Mar.

At the time of writing, we have >250 delegates registered from 37 different countries. They will encounter a packed and exciting scientific programme with 4 plenaries, >100 oral and >125 poster presentations covering 10 different scientific themes. IsoEcol 2018 will follow the tradition IsoEcol single common session format which has done so much to drive cross-disciplinary discussion in what is a very diverse field. This has restricted the number of oral presentations slots we can offer, so we will have three extended evening poster sessions, allowing full exposure of this important scientific component. Following recent IsoEcol meetings we have also included 6 specialist workshops (4 of which are run by our plenary speakers) that will be held in parallel with the main meeting. One new thing we have introduced is lunchtime talks recognising the contributions of key isotope ecologists: Brian Fry and Marilyn Fogel.

Like previous IsoEcol meetings, IsoEcol 2018 will bring together an exciting global mix of researchers from different career stages from universities, industry and government, all with common interests in the development and application of stable isotope techniques to the ecological sciences. One of the reasons that this works so well is that IsoEcol is rightfully recognised as one of the friendliest and welcoming meetings in the scientific calendar. We will maintain this record here in Viña del Mar, providing an environment where students, early career researchers and established scientists can meet and talk isotope ecology in a friendly, safe and sociable atmosphere. The social side of the conference includes a welcome reception, drinks and snacks during poster sessions and finally, the conference dinner. Following Latin American conference tradition, the dinner will be followed by a party, so if you are so inclined, please bring your dancing shoes.

Traditionally, IsoEcol includes mid-conference field trips – these allow more discussion and networking, but also allow delegates to get to know the area they are visiting. We have arranged five different trips that will allow delegates to discover Chilean wine, tour the cities of Valparaíso and Viña del Mar, hike La Campana mountain, follow the Pablo Neruda trail, or go sea-fishing.

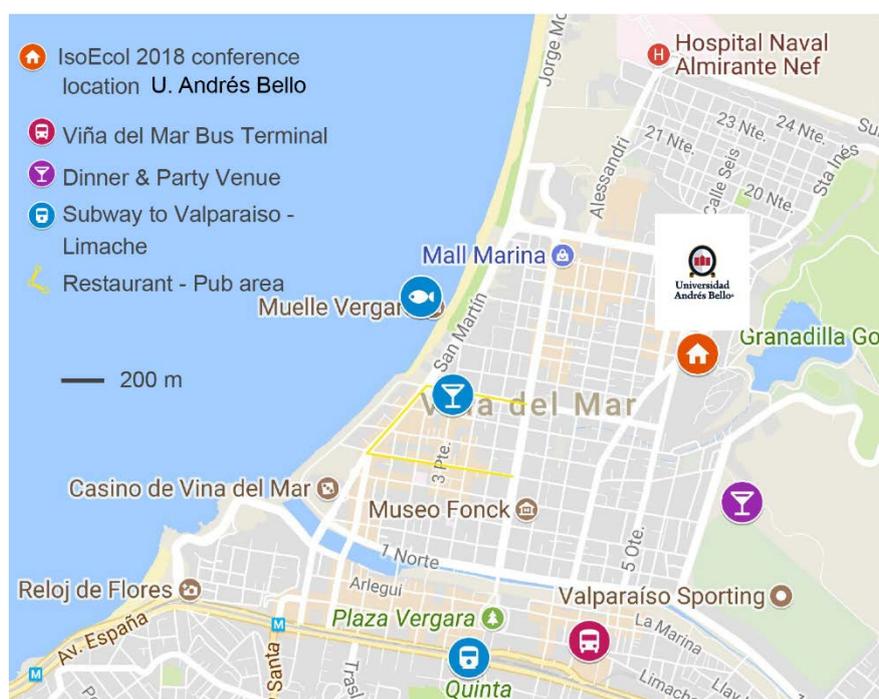
We must thank our hosts at la Universidad de Andrés Bello for providing the fantastic space for IsoEcol, our home universities for allowing us the time to organise and convene the meeting, 4id.cl who have dealt so efficiently with the administration of the conference and finally the sponsors whose kind support allowed us to offer fellowships covering registration and accommodation for 25 student delegates.

Dr Chris Harrod (Universidad de Antofagasta)
Dr Camila Fernández (CNRS-Observatoire Oceanologique de Banyuls sur Mer/ Universidad de Concepción)
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Dr Francisca Santana-Sagredo (Universidad de Antofagasta)
Dr Maritza Sepúlveda (Universidad de Valparaíso)
Dr Sebastian Klarian (Universidad de Andrés Bello)
Dr Verónica Molina (Universidad de Playa Ancha)

CONFERENCE ARRANGEMENTS:

All scientific activities (presentations and workshops) will be held at the Viña del Mar Campus of the Universidad de Andrés Bello (street address Quillota 980, Viña del Mar, Región de Valparaíso, Chile). The main conference will be held in the Main Auditorium (*Auditorio Mayor*) located on Floor -1 (Piso -1). Poster sessions and reception activities will be held in the Hall area of Floor -1, where you will also be able to find the exhibitors' stalls. Workshops will be held in various locations (see Workshop section for details).

A reception desk will be staffed throughout the conference in the reception/poster session space



Map of Viña del Mar (Source Google Maps). Full map [here](#)

Welcome Reception and Icebreaker: This will be held between 19:00 and 21:00 on Sunday 29 July in the Hall area on Floor -1. This is free to all delegates.

Registration: will be available 8:00 to 09:30 on Monday 30 July.

Internet: Wireless internet will be available and access credentials will be provided to delegates on registration.

Meals: Morning coffee/tea, a light lunch and afternoon coffee/tea will be provided. If you have not already done so, please inform the organising committee of any specialised dietary requirements at least 72 hours before the conference.

Conference dinner and party:

The conference dinner will be held from 20:00 on Friday 3 August in the Derby Room of Club Sporting Valparaíso (see map). It will be followed by the conference party which will run to very late. Tickets must be purchased via the 4id.cl website prior to the dinner. Please inform the organising committee of any specialised dietary requirements at least 72 hours before the dinner.

SUMMARY OF SCHEDULE

Day	Morning	Afternoon	Evening
Sat 28 July 2018	<i>Workshop 1</i>	<i>Workshop 1</i>	—
Sun 29 July 2018	<i>Workshop 2</i>	<i>Workshop 2</i>	<i>Welcome reception & icebreaker</i>
Mon 30 July 2018	<p><i>Registration</i></p> <p><i>Opening ceremony</i></p> <p><i>Talks</i> <u>Plenary: Diane O'Brien</u></p> <ul style="list-style-type: none"> — New methods and models in isotope ecology I 	<p><i>Talks:</i></p> <ul style="list-style-type: none"> — Isotope ecology from individuals to communities I — Soil isotope ecology 	<p><i>Poster session 1</i></p> <ul style="list-style-type: none"> — Isotope ecology from individuals to communities A — Soil isotope ecology — Archaeology and palaeoecology
Tues 31 July 2018	<p><i>Talks</i> <u>Plenary: Pablo Sabat</u></p> <ul style="list-style-type: none"> — Isoscapes and movement ecology — Biogeochemical cycles and global change 	<p><i>Talks</i></p> <ul style="list-style-type: none"> — Biogeochemical cycles and global change (cont...) — Microbial isotope ecology — Plant isotope ecology — Physiology and biochemistry 	<p><i>Workshop 3</i> <i>Poster session 2</i></p> <ul style="list-style-type: none"> — Biogeochemical cycles and global change — Isoscapes and movement ecology — Isotope ecology from individuals to communities B — Microbial isotope ecology — Physiology and biochemistry — Plant isotope ecology — Tribute to Brian Fry
Wed 1 August 2018	Field trips	Field trips	—
Thu 2 August 2018	<p><i>Talks</i> <u>Plenary: Andrew Jackson</u></p> <ul style="list-style-type: none"> — Isotope ecology from individuals to communities II 	<p><i>Talks</i></p> <ul style="list-style-type: none"> — Isotope ecology from individuals to communities II (cont...) — Isotope ecology from individuals to communities II — Archaeology and Palaeoecology I 	<p><i>Workshop 4</i> <i>Poster session 3</i></p> <ul style="list-style-type: none"> — Isotope ecology from individuals to communities C — New methods and models in isotope ecology
Fri 3 August 2018	<p><i>Talks</i> <u>Plenary: Tamsin O'Connell</u></p> <ul style="list-style-type: none"> — Archaeology and Palaeoecology II — New methods and models in isotope ecology II 	<p><i>Talks</i></p> <ul style="list-style-type: none"> — New methods and models in isotope ecology II (cont...) — Isotope ecology from individuals to communities III <p><i>Closing ceremony and presentation of awards</i></p>	<i>Conference dinner & party</i>
Sat 4 August 2018	—	<i>Workshop 5</i> <i>Workshop 6</i>	—

PRESENTATION FORMATS:

Oral presentations: Please save your files in either **.PPTX** (PowerPoint 2016) or **.PDF** format. The projector is 16:9 format, so it is possible to use a widescreen format. We'll be using a Windows based PC, so if you have used another OS for your presentation, please check that it still looks as you intended when viewed on a PC.

Plenary talks will be 45 minutes + 15 for questions. **Standard oral presentations will be 12 minutes + 3 for questions.** Session chairs will be strict with timing, so please practice your talk in advance.

Please save your talk on a USB stick (use of personal laptops not permitted due to time constraints) and pass it to a member of the organising committee the day before you are scheduled to talk. Those due to talk on Monday 30 July should bring them to the evening reception.

Filename: Please name your file using the following format: **YY-MM-DD_CODE.PPTX** (or .PDF) where **YY-MM-DD** is the date of your talk, and **CODE** is the abstract code for your presentation (see schedule or abstract for codes).

Social media: It is important to note that social media is playing an increasing role in scientific conferences, and we expect (and hope) that there will be much discussion and diffusion of studies presented at IsoEcol 2018 via social media such as Twitter, Facebook and Instagram (**#IsoEcol2018**). If you do not want people to discuss your work on social media, please make this clear at the start of your talk. Alternatively, if you are happy, you can let us know.

Poster presentations: Posters should be printed in **A0 Portrait** (Width x Height = 841 x 1189 mm; 33.1 x 46.8 inches). **Please do not print your poster in landscape** as there will not be room for it! Poster sessions will be held from 19:00 – 21:00 on Monday 30, Tuesday 31 July and Thursday 2 August in the **Hall area of Floor -1**. All posters have an individual abstract code (see schedule and abstract book for codes) and this will be printed on your poster location. Please display your posters in the morning so that delegates can read them during the coffee and lunch breaks. Then please stand by your poster between 19:00 – 21:00. Drinks and snacks will be provided.

Student awards: Prizes for best (and runner up) student oral and poster presentations will be awarded during the closing ceremony on Friday evening.

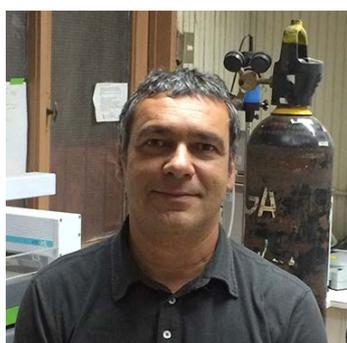
PLENARY SPEAKERS: We have four exceptional plenary speakers, all of whom are leading mid-career scientists using stable isotopes in different ways to improve our understanding of ecology. Chosen to represent the great possibilities that stable isotope analysis offer, they are also recognised leaders in their field.

DR DIANE O'BRIEN, PROFESSOR OF BIOLOGY, INSTITUTE OF ARCTIC BIOLOGY AND THE DEPARTMENT OF BIOLOGY AND WILDLIFE, UNIVERSITY OF ALASKA FAIRBANKS, USA.



Diane is a Professor of Biology at the University of Alaska Fairbanks, in the Institute of Arctic Biology and the Department of Biology and Wildlife. She earned her PhD in Ecology and Evolutionary Biology from Princeton University in 1998, where she worked with Dr Carlos Martinez del Rio, and was a postdoctoral fellow at Stanford University, with dir. Carol Boggs, and at the Carnegie Institution of Washington Geophysical Laboratory, with Dr Marilyn Fogel until 2003. She held a faculty appointment at Wellesley College before moving to the University of Alaska Fairbanks in 2004. Her research focuses on the intersection of diet, metabolism and physiology and how stable isotope approaches can be informative tools for dietary and metabolic research. She and her trainees have applied these approaches to a wide range of taxa, including insects, seabirds, ground squirrels, microbes, plants, worms, seals, foxes, fruit flies and most recently, humans. Currently her research is focused on validating stable isotope ratios as tools for objective dietary assessment in human nutritional epidemiology, and has worked with Alaska Native populations and multiple clinical trials including the US Women's Health Initiative (WHI). She is particularly interested in compound-specific stable isotope approaches to assessing diet.

DR PABLO SABAT, TITULAR (FULL) PROFESSOR, DEPARTAMENTO DE CIENCIAS ECOLÓGICAS FACULTAD DE CIENCIAS, UNIVERSIDAD DE CHILE, SANTIAGO, CHILE.



Pablo has developed an original line of [research](#) that explicitly incorporates ecological variables (biotic and abiotic) into the study of the physiological capacities of vertebrates. Specifically, it has focused on the mechanisms that determine the geographical distribution and dietary habits of vertebrates. His work has emphasized intra- and intra-specific differences as well as ontogenetic and seasonal changes in response to the environmental challenges experienced by amphibians, reptiles, birds and mammals. In this sense the mere fact of studying endemic groups and in some cases unique in terms of their ecology is an important advance in terms of ecological physiology, but also, the incorporation of the use of stable isotopes as an indicator of the origin and physicochemical characteristics of diet are the first studies of this nature that has been carried out not only in Chile, but are part of the few works published in general.

DR ANDREW JACKSON, ASSOCIATE PROFESSOR, DEPARTMENT OF ZOOLOGY, TRINITY COLLEGE DUBLIN, IRELAND.



Andrew's research interests lie in understanding ecological systems from an evolutionary perspective. He typically approaches these questions using computational / mathematical models to understand how the nuts and bolts of these systems work. Much of Andrew's current research focuses on understanding interactions among individual animals, particularly from the perspective of movement ecology and foraging ecology. What started as a side-line project some years ago, building Bayesian models as solutions for problems in stable isotope ecology has grown into a main focus of his current research. Aside from methods development, Andrew is involved in projects applying stable isotopes and these new methods in situations as diverse as blue whales, museum specimens, cooperation in mongoose and water quality metrics. Most recently he has started working with colleagues and collaborators on stability in food webs, both theoretical and empirical, and his worlds of isotopes, foraging ecology and stability analysis are starting to collide.

DR TAMSIN O'CONNELL, SENIOR LECTURER IN BIOARCHAEOLOGY, DEPARTMENT OF ARCHAEOLOGY, UNIVERSITY OF CAMBRIDGE, UK



Isotopic analysis is increasingly successful in archaeology and ecology as a method to study questions of resource use, behaviour and environment, but most researchers apply established techniques rather than develop our understanding of the causal science. The [thread linking all of Tamsin's work](#), by contrast, is probing the fundamental tenets and assumptions of this technique: why do we see the isotopic signals that we do, and how can we improve our interpretations through a better comprehension of their cause? Her research work has demonstrated that answering these questions is relevant to archaeology, ecology, animal and human physiology, and epidemiology. Tamsin is particularly interested in nitrogen metabolism – after >30 years of research, we still haven't worked out why we see a trophic level enrichment. She says that she is geekily pleased to have worked on material from all seven continents of the world, and to have published on all sorts of samples from 200kyr old mammoths to her colleagues' hair.

FIELD TRIPS: IsoEcol meetings traditionally include a mid-week break to allow delegates to relax, experience local culture and wildlife, and to network with colleagues outside of the lecture theatre through a series of pre-arranged field trips. This year we have arranged five field trips that range from the very gentle, through to the mildly stimulating and all the way to the physically demanding. Other delegates may choose to explore what the region has to offer under their own steam.

Note that:

- All Field Trips will take place on Wednesday 1 August 2018.
- The costs detailed below (in Chilean Pesos) are for guidance only and may be reduced depending on the number of participants for each field trip [not Trip 5 as we are limited to 24].
- A field trip option may be cancelled if there are insufficient registrants. In this case delegates will be given the option to transfer to another open field trip.
- August is late [winter in Chile](#) and it is important that suitable clothing and footwear is worn for each trip.

Trip 1: Casablanca Valley vineyard tour

Cost: CLP \$ 75 000

Capacity: 35

The world-famous Casablanca Valley is located at the base of the Coastal Cordillera, ca. 30 km from Viña del Mar. In this trip, we will depart at 9:00, visit two vineyards (and taste their wines), eat lunch, and return by approx. 16:00. This trip includes: Round-trip transfer from hotel, the entrance fee to two vineyards (Casas del Bosque and Emiliana), including tour with a local winery guide and tasting (3 wines). The price does not include tips or lunch (approx. CLP \$ 20 000)

Trip 2: City tours of Viña del Mar and Valparaíso

Price: CLP \$ 30 000

Capacity: 35

This trip is a guided tour through the main tourist spots of the two contrasting cities of Viña del Mar and Valparaíso. The tour includes the flower clock, Easter Island Moai, Reñaca beach, Quinta Vergara, panoramic view on Pablo Neruda's La Sebastiana, historical centre of Valparaíso, Sotomayor square, Valparaíso harbour and some of the UNSECO's world heritage neighbourhoods in Valparaíso' hills.

The trip will depart at 9:00, returning approx. by 14:00. It includes round-trip transfer and a bilingual guide. It does not lunch or drinks (approx. CLP \$ 15 000).

Trip 3: Hiking in the La Campana Mountain National Park

Price: CLP \$ 65 000

Capacity: 35

La Campana mountain (1 180 m) forms the heart of the La Campana National park in Central Chile. The wooded park harbours a diverse native flora including *Jubaea chilensis*, an endemic and very rare palm-tree and *Nothofagus*, among others and a large number of amphibians, reptiles, birds and mammals. La Campana is a lovely place, with a unique microclimate due to oceanic moisture that often materialise during the morning. Charles Darwin visited La Campana hill in August 1834 during his explorations in South America and marvelled at the views, which remain stunning to this day.

We offer 2 options for those undertaking the trip: level 3 (medium-easy difficulty) and level 4 (hard). Fitness levels those trekkers following the level 3 hike should be average, working out or doing cardiovascular exercise (cycling, running, swimming) once a week. The trek will take between 4-6 hours, with a total distance covered between 6-12 km and altitude difference between 200 and 500 m. Fitness levels for those choosing the level 4 hike should be good, i.e. working out or doing cardiovascular exercise (cycling, running, swimming) at least twice a week. The hike will take between 6-8 hours, covering a distance between 12 and 18 km and ca. 500-900 m difference in altitude. The coach will leave the pick-up point early (7:00) and will leave the national park at between 18:00 and 19:00 (times subject to change).

Hikers will need to bring suitable boots and clothes, a backpack, a warm and waterproof jacket, 2 litres of water, food and snacks. The trip includes bilingual guide, round-trip transfer and trekking sticks. It does not include lunch, drinks or snacks (or life/ accident insurance).

NB: the collection of biological, geological or soil samples is not permitted from Chilean national parks unless a permit has been issued by the Corporación Nacional Forestal (CONAF).

Trip 4: Pablo Neruda cultural tour – Isla Negra and Pomaire

Cost: CLP \$ 55 000

Capacity: 35

Pablo Neruda, Chilean poet and winner of the 1971 Nobel Prize for Literature had several residences in Chile. One of the most iconic is found in the small coastal town of Isla Negra, located 60 km south of Viña del Mar, and it is here where he is buried. The house is now a museum that is unmissable to any admirer of this internationally renowned poet, and includes large collections of figureheads, model boats and other items associated with the sea, navies and sailors' life. The trip will depart from Viña del Mar at 8:15, first visiting Isla Negra, then moving on to Pomaire, a typical small town of central Chile, famous for its earthenware pottery that plays a key role in some of Chile's most characteristic dishes. The cost includes the round-trip transfer from the hotel, the entrance ticket to Museum Isla Negra. It does not include lunch.

Trip 5: Sea fishing

Cost: CLP \$ 35 000

Capacity: 24

NB: This trip is weather dependent as swells on the Pacific coast of Chile can be extremely 'impressive'. If the weather smiles on us, this trip will allow delegates to sample boat fishing for a range of Chilean coastal fishes guided by ace angler, local fisheries biologist and IsoEcol organiser Sebastian Klarian. We will travel from Viña del Mar at 9:00 to the charming fishing village of Quintay, where Universidad de Andrés Bello have their marine station. We will fish during the morning and then return to the laboratory and eat lunch in one of the picturesque restaurants. We will then return to Viña del Mar in the late afternoon. The trip includes the round trip, and the loan of fishing equipment. It does not include lunch or drinks. Those joining this trip should bring warm and waterproof clothes and a sense of humour.

PROGRAMME SCHEDULE



Programme schedule Monday 30 July 2018

Mon 30.7.18	Activity	Abstract code
08:00 – 09:30	Registration (Main Hall, Floor -1)	
09:30 – 10:00	Welcome and opening ceremony	
10:00 – 11:00	Plenary 1: Diane O'Brien. Stable Isotope ratios as biomarkers of diet in human health research.	
11:00 – 11:30	Coffee break	
Session	<u>New methods and models in isotope ecology I</u> Chair: Jason Newton	
11:30 – 11:45	* <i>Baptiste Le Bourg</i> . Preservation methodology and stable isotope composition in sea stars: Can museum collections be useful for trophic ecology studies?	BG417CT
11:45 – 12:00	<i>Stanislas Dubois</i> . Do isotopic spaces represent food webs properties? A theoretical framework seeking for empirical data.	GN842TF
12:00 – 12:15	<i>Leonard Wassenaar</i> . The new Titanium Method: a simple, one-step reduction of aqueous NO ₃ ⁻ to N ₂ O for IRMS or Laser-based analysis of δ ¹⁵ N, δ ¹⁸ O, and δ ¹⁷ O.	JP719KM
12:15 – 12:30	<i>Xinhua He</i> . Nano-scale secondary ion mass spectrometry (nano-SIMS) images can differentiate soil organo-mineral complexes and associated carbon preservation.	JT236HR
12:30 – 12:45	<i>Alicia Guerrero</i> . Applying the Bayesian mixing model MixSIAR to fatty acid and stable isotope data to estimate diet of Antarctic seals	KT184TD
12:45 – 13:00	<i>Trevor Krabbenhoft</i> . Integrating gene expression with stable isotopes and other trophic ecology datasets: a conceptual and quantitative framework	MC498KN
13:00 – 14:00	LUNCH (provided)	
Session	<u>Isotope ecology from individuals to communities I</u> Chair: Sarah Bury	
14:00 – 14:15	* <i>Jessica Johnson</i> . Compound-specific isotope analysis of amino acids indicates human dietary exposures in a clinical feeding study.	BD235BG
14:15 – 14:30	<i>Keith Hobson</i> . Using stable carbon and hydrogen isotope analyses of lipids and breath CO ₂ to infer sources of fueling in migratory birds and insects.	BL192BS
14:30 – 14:45	<i>Alexei Tiunov</i> . Isotopic outliers: detecting functional rarity.	BR957JM
14:45 – 15:00	<i>Laurent Simon</i> . Food webs in subterranean ecosystem: is omnivory a necessity in extreme low-productivity environment?	CC493DH
15:00 – 15:15	* <i>Yota Harada</i> . The food web consequences of a massive dieback of mangrove forest in the Gulf of Carpentaria, Australia.	CJ139HR
15:15 – 15:30	<i>Kelton McMahon</i> . Amino acid isotopes in penguin feathers reveal a history of climate change and historic whaling in the Antarctic Peninsula.	CQ278PJ

Mon 30.7.18	Activity	Abstract code
15:30 – 15:45	<i>Brian Hayden</i> . Climate and productivity drive regime shifts in subarctic lake food webs.	CS989PF
15:45 – 16:00	<i>Maria Ana Correia</i> . Detecting the "famine relief diet" through stable isotope analysis: a case study from tropical Africa	DB878NJ
16:00 – 16:30	Coffee break	
<i>Chair: Sebastian Klarian</i>		
16:30 – 16:45	<i>Luis Huckstadt</i> . Trophic web overlap between southern elephant and crabeater seals.	DD228KR
16:45 – 17:00	* <i>Adelaide Dedden</i> . Diet as an important factor of male status in the southern elephant seal (<i>Mirounga leonine</i>).	DN845BH
17:00 – 17:15	<i>James Ehleringer</i> . Deciphering the significance of intrapopulation variations in plant carbon isotopes.	FP269RJ
17:15 – 17:30	<i>Ming-Tsung Chung</i> . Fish physiological responses to environmental changes revealed by otolith metabolic proxy.	FQ985RG
17:30 – 17:45	<i>Melanie Maraun</i> . Adaptation of compound-specific amino acid analyses (¹³ C and ¹⁵ N) for analyzing the structure of soil animal food webs .	GJ369SG
17:45 – 18:00	* <i>Veronica Radice</i> . Shifts in trophic strategies of reef-building corals following seawater temperature anomaly.	HB134TQ
Session	Soil isotope ecology	Chair: Verónica Molina
18:00 – 18:15	<i>Anton Potapov</i> . Uncovering soil food webs using bulk natural stable isotope composition	GM262JJ
18:15 – 18:30	* <i>Giovanny Mosquera</i> . How do wetlands and grasslands influence the ecohydrological functioning of the Andean Paramo?	PD387PF

19:00 – 21:00 **Poster session 1**
Isotope ecology from individuals to communities A
Soil isotope ecology
Archaeology and palaeoecology

Programme schedule Tuesday 31 July 2018

Tues 31.7.18	Activity	Abstract code
08:45 – 09:00	Welcome and announcements	
09:00 – 10:00	Plenary 2: Pablo Sabat. Evolutionary and phenotypic responses to the use of marine resources in terrestrial songbirds: lessons from isotopic ecology	
Session	Isoscapes and movement ecology	Chair: Keith Hobson
10:00 – 10:15	<i>Tim Jardine</i> . Applications of sulphur isotopes in freshwater food webs.	BD181CN
10:15 – 10:30	<i>Daniel Gorman</i> . Land-ocean connectivity in a Brazilian subtropical bay: using $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isoscapes to link terrestrial inputs, algae and benthic consumers.	BD564GS
10:30 – 10:45	<i>Hannah Vander Zanden</i> . The geographic extent of solar energy effects on California avian populations.	FK877SK
10:45 – 11:00	<i>Clive Trueman</i> . Models, migration and connectivity.	GK821CT
11:00 – 11:30	Coffee break	
11:30 – 11:45	<i>Gabriela Nardoto</i> . Source-consumer isoscapes reveal an uncoupling of energy and protein inputs in human diet with local carbon and nitrogen sources in Brazil.	HB774GP
11:45 – 12:00	* <i>Nicolas Lazzarini</i> . Can we track livestock mobility using high-resolution of C & N isotopic analysis of keratin? A case study using GPS tracking in the Mongolian Altai	KN537RG
12:00 – 12:15	<i>Sarah Bury</i> . Latitudinal isotopic variability in Southern Ocean suspended particulate organic matter validates Southern Ocean isoscapes and informs humpback whale trophic ecology.	LL458LQ
12:15 – 12:30	<i>Katie St John Glew</i> . New methods of isoscape development: the good, the bad and the variability.	MC576SB
12:30 – 12:45	<i>Yanina Poblete</i> . Intraspecific variation in exploratory behavior and elevational affinity in <i>Zonotrichia capensis</i> .	TD383JN
Session	Biogeochemical cycles and global change	Chair: Len Wassenaar
12:45 – 13:00	<i>Jonathan Grey</i> . Carbon, chironomids, and climate change.	BL746MJ
13:00 – 14:00	LUNCH (provided) Lunchtime presentations: Tribute to Brian Fry <i>Tim Jardine</i> . Writing the isotope symphony: Brian Fry's legacy. <i>Brian Fry</i> . "ISOTOMICS" or reading the big books (tomes) of position-specific isotope analysis (PSIA) information; initial amino acid PSIA studies of fish and prawns from a marine food web, Moreton Bay, Australia.	QK745JP
14:00 – 14:15	<i>Ayumi Hyodo</i> . Does biochar amendment reduce N_2O emissions by stimulating the last step of denitrification? - A study using position-specific N isotopic composition.	CR667HQ
14:15 – 14:30	<i>Francisco Fernandez</i> . Stable water isotopes as climate tracers in the Laclavere Plateau, Antarctic Peninsula.	DR395CT
14:30 – 14:45	<i>Lixin Wang</i> . Non-rainfall water origins and formation mechanisms in the Namib Desert.	FT283GP

Tues 31.7.18	Activity	Abstract code
14:45 – 15:00	<i>Kebonyethata Dintwe</i> . Isotopic analysis of soil organic carbon: critical insights into belowground tree-grass interactions in savanna ecosystems	HB243PK
15:00 – 15:15	<i>Cristian Vargas</i> . Applications of carbon stable isotopes in marine carbonate system and ocean acidification studies.	LT199NM
15:15 – 15:30	<i>Jorge Nimptsch</i> . $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotope proportion in effluents of land-based fish-farms in north-Patagonian streams	PJ825KJ
15:30 – 15:45	<i>Leandro Bergamino</i> . Geochemical evidence of predominantly autochthonous organic carbon contributions to the sedimentary organic matter pool of Laguna Garzon in Uruguay	RR699JL
15:45 – 16:00	<i>Carolyn Kurle</i> . Reconstructing decades of food web structure in the North Pacific and Bering Sea using bulk and compound-specific stable isotope analyses from archived northern fur seal teeth.	SB899CP
16:00 – 16:30	Coffee break	
Session	<u>Microbial isotope ecology</u>	Chair: Claudio Quezada-Romegialli
16:30 – 16:45	<i>Seth Newsome</i> . Examining the role of gut microbes in host protein metabolism: linking microbial community composition with amino acid $\delta^{13}\text{C}$ analysis.	BF872QQ
16:45 – 17:00	* <i>Inga Conti-Jerpe</i> . Nitrate assimilation in aposymbiotic corals	PF117QF
Session	<u>Plant isotope ecology</u>	Chair: Francisca Santana
17:00 – 17:15	* <i>Philipp Gieseemann</i> . A multi-element stable isotope natural abundance approach indicates partial mycoheterotrophy for Central European <i>Equisetum</i> species.	DF178QN
17:15 – 17:30	<i>Oliver Kracht</i> . Wood Analysis: advances in bulk analytical techniques and considerations on accuracy of isotope ratio determination.	LG975HN
17:30 – 17:45	<i>Gerhard Gebauer</i> . Stable isotopes elucidate more and more facets of mycoheterotrophic carbon gain among plants.	LL741NK
Session	<u>Physiology and biochemistry</u>	Chair: Claudio Latorre
17:45 – 18:00	* <i>Maria Teresa Nuche-Pascual</i> . Amino acid-specific $\delta^{15}\text{N}$ trophic enrichment factor in fish fed with formulated diets varying in protein quantity and quality.	BD665RK
18:00 – 18:15	* <i>Michael Fox</i> . Amino acid $\delta^{13}\text{C}$ analysis reveals trophic plasticity in a common reef-building coral.	CK268QN
18:15 – 18:30	<i>John Whiteman</i> . Advancing physiology: a single-sample method to measure the metabolic water contribution to animal body water.	GK166JM
19:00 – 21:00	Poster session 2 Biogeochemical cycles and global change Isoscapes and movement ecology Isotope ecology from individuals to communities B Microbial isotope ecology Physiology and biochemistry Plant isotope ecology Tribute to Brian Fry	
18:45 – 20:30	Workshop 3 - attendance by pre-registration only.	

Wednesday 1 August

Field trips

http://isoecol.com/2018/IsoEcol2018_Field-Trips.html

Trip 1: Casablanca Valley vineyard tour

Trip 2: City tours of Viña del Mar and Valparaíso

Trip 3: Hiking in the La Campana Mountain National Park

Trip 4: Pablo Neruda cultural tour – Isla Negra and Pomaire

Trip 5: Sea fishing

Programme schedule Thursday 2 August 2018

Thurs 2.8.18	Activity	Abstract code
08:45 – 09:00	Welcome and announcements	
09:00 – 10:00	Plenary 3: Andrew Jackson. Using ecological theory to maximise information recovery from stable isotope data.	
Session	Isotope ecology from individuals to communities II Chair: Brian Hayden	
10:00 – 10:15	<i>Rachel Welicky</i> . Do "tongue-biters" bite their hosts? The use of stable carbon and nitrogen isotope analyses to describe the foraging strategies of fish parasitic cymothoid isopods with respect to attachment site.	HJ879HN
10:15 – 10:30	<i>Gilles Lepoint</i> . Macrofauna as vectors of seagrass organic matter transfer in <i>Posidonia oceanica</i> macrophytodetritrus accumulation	HN764SK
10:30 – 10:45	* <i>Jessica Duffill Telsnig</i> . Estimating contributions of pelagic and benthic pathways to consumer production in coupled marine food webs	HT414NN
10:45 – 11:00	<i>Andrew Revill</i> . Trophic interactions of deep-sea (200 – 3 000 m) benthic fauna identified from compound specific stable isotope analysis of amino acids.	HT639TT
11:00 – 11:30	Coffee break	
11:30 – 11:45	* <i>Matthew Tietbohl</i> . Insights from compound-specific isotope analysis into the nutritional ecology of herbivorous reef fishes.	JD316QP
11:45 – 12:00	<i>Iván González Bergonzoni</i> . Aliens vs. Fish: An invasive Asian mussel (<i>Limnoperna fortunei</i>) alters food webs, and trophic niche in native fish species that partially limit their abundances.	PR477PD
12:00 – 12:15	* <i>Matthew Cobain</i> . The forgotten dimension: how important is time to isotope ecology?	KR282MS
12:15 – 12:30	<i>Igor Eulaers</i> . Temporal food web changes in Greenland's priority marine conservation regions: Insights from bulk and compound-specific stable isotopes and fatty acids.	LJ986LR
12:30 – 12:45	<i>Brian Hunt</i> . Integrated stable isotope approaches to full salmon life history analysis.	LM579GP
12:45 – 13:00	* <i>Bobby Nakamoto</i> . Freshwater particulate organic matter and trophic webs in a riverine watershed.	LP717MC
13:00 – 14:00	LUNCH (provided) Lunchtime presentations: Tribute to Marilyn Fogel Seth Newsome. Figure(d) it out: the pioneering career of Marilyn Fogel	
	Chair: Tracey Rodgers	
14:00 – 14:15	<i>Francisco Squeo</i> . A positive relationship between plant height and leaf $\delta^{13}\text{C}$ at the species- and community-level in the Atacama Desert.	NG427HP
14:15 – 14:30	* <i>Benjamin Lejeune</i> . Global food web alteration following goldfish introduction in palmate newt dominated pond ecosystem.	PB481SP
14:30 – 14:45	<i>Carlos Polo</i> . Trophic inferences of lionfish in the Colombian Caribbean from stable isotope analysis.	PB521LP

Thurs 2.8.18	Activity	Abstract code
14:45 – 15:00	* <i>Margaux Mathieu-Resuge</i> . Local and oceanic inputs into the trophic ecology of two bivalve species in a coastal lagoon: evidences from stable isotope, fatty acid and compound specific isotope analyses.	PG695LJ
15:00 – 15:15	* <i>Matthew Ramirez</i> . Intrapopulation variation in resource use by Kemp's ridley sea turtles revealed through combined skeletal and stable isotope analyses.	PG853GT
15:15 – 15:30	* <i>Kate Tuckson</i> . Translocated top predator, the Tasmanian devil shows seasonal niche flexibility.	PH662NN
15:30 – 15:45	<i>Loïc Michel</i> . Environmental parameters and biotic interactions influence chemosynthesis-based food webs supporting deep-sea cold seeps communities off West Africa.	PM136FK
15:45 – 16:00	* <i>Natasha Phillips</i> . Bulk & CSIA reveals the complex trophic ecology of ocean sunfishes, identifying global ontogenetic patterns.	PM534GP
16:00 – 16:30	Coffee break	
Session	<u>Archaeology and Palaeoecology I</u>	Chair: Paul Szpak
16:30 – 16:45	<i>Jessica Metcalfe</i> . 'Meat of the matter': the effects of seasonal selectivity, food storage, and tissue turnover rates on human paleodiet reconstructions	CD322BH
16:45 – 17:00	* <i>Emma Elliott Smith</i> . Amino acid d13C analysis quantifies environmental change in a nearshore ecosystem through the Late Holocene.	CP894RG
17:00 – 17:15	<i>Christophe Snoeck</i> . From Tarapacá to Stonehenge – the challenge of mummies and cremated bones	DF579HT
17:15 – 17:30	* <i>Chantel Michelson</i> . Deciphering millennial-scale Antarctic ecosystem change using amino acid stable isotope analysis of modern and ancient penguin eggshell.	DH387GF
17:30 – 17:45	<i>Hervé Bocherens</i> . Isotopic insight on the palaeobiology of late Pleistocene giant ground sloths in the southern Cone of South America.	HK144TC
17:45 – 18:00	<i>Claudio Latorre</i> . A rodent midden leaf-wax $\delta^2\text{H}$ record reveals shifting sources of tropical moisture over the last 1700 yrs. in the Andes of northernmost Chile.	JM669GQ
18:00 – 18:15	<i>Carola Flores</i> . Nearshore paleoceanographic conditions and human adaptation on the coast of the Atacama Desert (Taltal, 25°S) during the Early and Middle Holocene. Oxygen isotope analyses ($\delta^{18}\text{O}$) on <i>Fissurella maxima</i> shells	KL574MN
18:15 – 18:30	<i>Priscilla Wehi</i> . Tracking trophic shifts through time in a threatened parrot.	KQ362QL
19:00 – 21:00	Poster session 3 Isotope ecology from individuals to communities C New methods and models in isotope ecology	
18:45 – 20:30	Workshop 4 – attendance by pre-registration only.	

Programme schedule Friday 3 August 2018

Fri 3.8.18	Activity	Abstract code
08:45 – 09:00	Welcome and announcements	
09:00 – 10:00	Plenary 4: Tamsin O'Connell. The isotopic complexity of complex organisms.	
Session	Archaeology and Palaeoecology II	Chair: Tamsin O'Connell
10:00 – 10:15	<i>Francisca Santana-Sagredo</i> . Stable isotope analysis in the Atacama Desert (northern Chile): complexities and challenges for archaeological and Andean studies.	NP958NT
10:15 – 10:30	<i>Elise Dufour</i> . Past Camelid herding and ritual practices on the northern coast of Peru revealed by stable isotopic analysis.	PF886LQ
10:30 – 10:45	<i>Fernanda Falabella</i> . Isotopic data on human mobility in prehispanic communities in Central Chile.	PM776NK
10:45 – 11:00	* <i>Jonathan Nye</i> . Humans, climate, pinnipeds, and their isotopic relationships from the Holocene to the Anthropocene in Tierra del Fuego.	QK265DT
11:00 – 11:30	Coffee break	
11:30 – 11:45	* <i>Juliette Funck</i> . The life and times of a mummified steppe bison (<i>Bison priscus</i>) from Arctic Alaska told through his isotopic and molecular chemistry.	RL891JR
11:45 – 12:00	<i>Matthew Wooller</i> . Tracking 30 years of movement and feeding ecology of a 17,000 year old woolly mammoth (<i>Mammuthus primigenius</i>) from Arctic Alaska.	TC791GF
Session	New methods and models in isotope ecology II	Chair: Tim Jardine
12:00 – 12:15	<i>Sarah Magozzi</i> . How do behaviour, the environment and physiology interact to produce variance in tissue isotopic compositions?	MS271PD
12:15 – 12:30	<i>Helen Atkinson</i> . Improvements in sensitivity in IRMS measurements.	PC961KT
12:30 – 12:45	* <i>Alexi Besser</i> . An essential amino acid $\delta^{13}\text{C}$ library for tracing the importance of biofilms and biocrusts in aquatic and terrestrial ecosystems.	PM343KG
12:45 – 13:00	<i>Sebastien Lefebvre</i> . Are my isotopic inferences distorted? Quantification of the isotopic anamorphosis at intra- and inter-species levels.	PP234RC
13:00 – 14:00	LUNCH (provided)	
14:00 – 14:15	<i>Sam Barker</i> . Introducing ArDB: the cutting-edge analytical results database and data visualisation software from Elementar.	QF351SF
14:15 – 14:30	<i>Pierre Cresson</i> . Functional traits unravel temporal changes in fish biomass production on artificial reefs.	SL154BM
14:30 – 14:45	<i>Christopher Brodie</i> . Advances in NCS analysis in EA-IRMS for Ecological Applications: Getting more for less with ultra-high sensitivity.	TT488FT
Session	Isotope ecology from individuals to communities III	Chair: Jon Grey
14:45 – 15:00	<i>Kirsteen MacKenzie</i> . Structure, function and pelagic-benthic coupling in the Norwegian Arctic marine ecosystem.	KC958RR

Fri 3.8.18	Activity	Abstract code
15:00 – 15:15	* <i>Christine Weldrick</i> . Inter- and intraspecific variability in isotopic niche widths of Southern Ocean pteropods.	PR859RC
15:15 – 15:30	<i>Pablo Cardenas</i> . The effects of C ₃ versus C ₄ plant biomass on a granivorous small mammal community in the Chihuahuan Desert	QF773SB
15:30 – 15:45	<i>Diana Szteren</i> . Intra and interspecific trophic niche overlap between South American fur seals and sea lions in Uruguay	QH421PR
15:45 – 16:00	<i>Sebastián Klarian</i> . Feeding habits and bioenergetics insights of jack mackerel (<i>Trachurus murphyi</i>) in south eastern Pacific waters.	RD181SP
16:00 – 16:30	Coffee break	
16:30 – 16:45	<i>Jost Borchering</i> . Combined stomach content and stable isotope analyses suggests that marked dietary overlap between invasive and non-invasive species may be mediated through habitat segregation	RF458BD
16:45 – 17:00	<i>Nicole Colin</i> . Impact of recycled water on the trophic interactions among top consumers in a semi-arid region.	RS269RQ
17:00 – 17:15	<i>Amanda Demopoulos</i> . Food-web dynamics and isotopic niches within two deep-sea canyons and adjacent slope habitats.	SC272KF
17:15 – 17:30	* <i>Ingrid Rabitsch</i> . Stable isotopes and stoichiometric analysis reveal ecosystem level impact of invasive raspberry species on Darwin warbler finch in native <i>Scalesia</i> forest	SM157HH
17:30 – 17:45	<i>Lorrie Rea</i> . Enhancing the interpretation of bulk (C and N) isotope oscillations in whisker samples from Steller sea lions using compound specific nitrogen isotope analyses of amino acids	ST933GS
17:45 – 18:00	<i>Chris Harrod</i> . Estimating jellyfish trophic position using bulk and amino acid $\delta^{15}\text{N}$ reveal strong and repeated agreements between methods, but marked differences between jellyfish species and capture locations.	JD938LT
18:10 – 19:00	Closing ceremony and presentation of awards	
20:00 – very late	Conference dinner and party at Valparaíso Sporting Club (Derby Room)	

POSTER PRESENTATIONS:

Poster session 1. Monday 30 July 19:00 — 21:00. Location Main Hall, Floor -1.

First author	Theme/Title	Abstract code
<u>Archaeology and Palaeoecology</u>		
Violeta Killian Galván	Imperial diets? Using stable isotope analysis to explore the local impact of the Inka Empire in Antofagasta de la Sierra (Catamarca, Argentina)	BC154NK
Kaycee E. Morra	Seasonal and decadal-scale foraging habits of three Hawaiian seabirds: insights from stable isotope analysis	CH378CG
Eric Guiry	Isotopic evidence from archaeological fish shows significant environmental change in past Great Lakes ecosystem	CJ185JH
Maria Eugenia de Porras	Into the tropical-extratropical rainfall systems interaction in the southern Atacama Desert since 17ka	DF288KC
Yuichi Naito	Paleodiets of late Quaternary humans and mammals inferred from nitrogen isotopic composition of individual amino acids in bone collagen	FD128TC
Paul Szpak	Impact of Prehistoric Human Hunters on the Foraging Ecology of the Arctic Fox	GB788SS
*Marie Grace Pamela Faylona	The Early Pleistocene environment in Java: A palaeoenvironmental reconstruction from stable isotope analyses of Sangiran fossil shells	GH963BG
* Jonathan Cybulski	Unravelling nutrient assimilation into the coral skeletal organic matrix has implications for historical interpretations	JG776BN
Yuichi Naito	Gazelle hunting activities around Tor Hamar rock-shelter in Jordan viewed from carbon and oxygen isotopic compositions of tooth enamel	JJ183DR
Damián Vales	Trophic ecology of fur seals and sea lions from northern Patagonia and their food webs through time	KB554HC
Augusto Tessone	$\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ herbivores variability in a longitudinal transect of southern Patagonia during the Holocene	KD427SP
Adolfo Gil	Variability in stable isotopes (^{13}C , ^{15}N) of camelid bone collagen: Implications for Holocene human paleoecology	LB931CD
Christopher Brodie	Simultaneous nitrogen, carbon and sulfur isotope analysis on bone collagen: A dietary recorder	MB848CD
<u>Biogeochemical cycles and global change</u>		
Kena Fox-Dobbs	The role of log mat biofilm in the Spirit Lake ecosystem after the eruption of Mount St. Helens	MT511BB
<u>Isoscapes and movement ecology</u>		
Ander de Lecea	Linking consumers' isoscapes to modelled primary production in the English Channel	QF614NR
<u>Isotope ecology from individuals to communities A</u>		
Claudia Andrade	Trophic study of the Southern King Crab <i>Lithodes santolla</i> in the Cape Horn Archipelago based on stomach content and carbon-and nitrogen-stable isotopes	BH389QR

First author	Theme/Title	Abstract code
Rocío Loizaga de Castro	Isotopic evidence of structuring killer whale groups along the Southwestern South Atlantic Ocean	BJ661PG
Bernal Ainhoa	Trophodynamics of ichthyo- and mesozooplankton from Chiloé's inner sea (Northern Patagonia) based on C and N isotopes	BQ869RP
Vivian Cionek	Landscape modification on the food web structure of Neotropical streams	BS261MM
* Thibault Androuin	Trophic relationships between co-occurring benthic suspension-feeding species, a matter of scale?	CB221PQ
*Luiza Pereira	Isotopic niche differentiation between bottlenose dolphin ecotypes of the western South Atlantic	CC657ML
Brian Hayden	Identifying the resource use of larval sea lamprey in their native habitat – novel insights from a four isotope approach	QR249HQ
Chris Harrod	Stable isotope analysis reveals varied foraging strategies and the importance of red algae in the diet of <i>Chelonia mydas</i> in the north of Chile	CC875PF
* Gonzalo Salazar	Stable isotopes and stomach contents analysis reveal complete niche partitioning between invasive juvenile rainbow trout and the endemic cyprinodontid <i>Orestias chungarensis</i> in the Río Chungará, N Chile.	BR332MN
*Elsa Fernández	Using stable isotopes to assess the utility of fatty acids biomarkers of pelagic and benthic resources in kelp-forest fishes	CM966RM
*Gonzalo Gómez	Using isotopic niche metrics to assess responses by soft-bottom macrobenthos to natural oscillations in dissolved oxygen concentrations in a upwelling-associated oxygen minimum zone.	CN464HS
Matías Ocampo Reinaldo	Using stable isotopes derived trophic position to improve mass-balanced food web models	CN554CF
David Costalago	Plankton food-web pathways to juvenile salmon.	CH326CQ
*Matthew Cobain	On the geometry of the isotopic niche	CT626LF
Quentin Peignot	Influence of environmental conditions on Antarctic Notothenioid trophic ecology in a context of global climate change	DC393KN
William Jenkins	Host feeding ecology and trophic position significantly influence isotopic discrimination between a generalist ectoparasite and its hosts: implications for parasite-host trophic studies	DD311BD
Lisette Zenteno	Following the food sources and trophic ecology of an Antarctic coastal benthic community	DH132HF
Juliana Ribeiro	Effect of locomotion habits and structural complexity of vegetation in the trophic niche of communities of small mammals of the Central Brazilian Savannas	DP421TB
*Fernanda Vargas	Analysis of trophic aspects in <i>Mustelus mento</i> (Cope 1877) in the central-northern zone of Chile, by studying stomach contents and stable isotopes	GC359KH

First author	Theme/Title	Abstract code
*Mairan Smith	The role of anthropogenic food sources in the diets of urban raccoons (<i>Procyon lotor</i>) and Virginia opossums (<i>Didelphis virginiana</i>) in the Pacific Northwest, USA	DQ566QC
Whiteman John	Carbon and nitrogen isotopes trace nutrients from wood on the ocean floor into microbial and animal communities	FJ185DF
*Tiago Kisaka	Isotopic assessment of benthic periphyton under open canopy and nutrient enrichment in shaded oligotrophic streams of Central Brazil	FQ975PQ
* Karla García	Trophic ecology and niche overlap between the invasive American mink and native European mink	KM665LN
* Gaël Le Croizier	Trophic competition and habitat connectivity between shark species from oceanic islands in the Northeastern Pacific.	NR478PD
Aliro Manosalva	Latitudinal variation of the tropic niche of puye <i>Galaxias maculatus</i> (Jenyns, 1842) in river systems in southern Chile (36 ° - 47 ° S)	QD486LD
Stefania Perez	Invasive juvenile salmon affect the diet of native puye <i>Galaxias maculatus</i> in Patagonian fjords	RM758FP
Iván González Bergonzoni	Origin of fish biomass in a diverse food web of a large subtropical river: increasing allochthonic biomass following flood pulses	TR463RP
<u>Plant isotope ecology</u>		
* Lara Meurer	Influence of climatic parameters on stable isotopes in scots pines in Potsdam, Germany	QL659CF
<u>Soil isotope ecology</u>		
Rebecca Hood-Nowotny	Impacts of nitrogen deposition on forest biogeochemical processes measured in new pools, across a trans-European gradient, investigated using a tool kit of stable isotope methods.	JH622SL

Poster session 2. Tuesday 31 July 19:00 — 21:00. Location Main Hall, Floor -1.

First author	Theme/Title	Abstract code
<u>Biogeochemical cycles and global change</u>		
Francisca Diaz	A 50,000 year $\delta^{15}\text{N}$ record of past variations in climate and nitrogen cycling from the Atacama Desert: terrestrial or marine sources?	CP249NF
Camilla Liénart	Dynamics of particulate organic matter composition in coastal systems: forcing of the spatio-temporal variability at multi-systems scale	DF982QF
Carla Roberta Gonçalves Reis	Assessment of leaf $\delta^{15}\text{N}$ and N concentrations as indicators of nitrogen dynamics in subtropical mangroves	FD583NN
Brian Hunt	Terrestrial contributions to the marine food web from pluvial watershed in the northeast Pacific Temperate Coastal Rainforest domain	GH543PH
Sebastián Crespo	Hydro-geochemical water inputs identification in glacierized basin hydrology	HD923GB
*Gabriela Polanco	Vertical and temporal variation in the concentration of stable isotopes of Nitrogen during upwelling events, in front of Punta Ángeles, Valparaíso.	HJ311HJ
*Connor Love	Hydrocarbon production by marine cyanobacteria in the open ocean: a precursor for the Oceans' ability to naturally recover from oil input	NJ737JL
*Jéssica Airisse Sampaio	Changes in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ by biological invasion in subtropical mangroves, Brazil	QC745MC
<u>Celebrating the contribution of Brian Fry to Isotope Ecology</u>		
Seth Newsome	Individual diet specialization in a community of granivorous small mammals living in a stochastic environment	SQ853TR
<u>Isoscapes and movement ecology</u>		
*Glauber Neves	The distribution $\delta^{13}\text{C}$ in the Central Brazilian Savanna and its historical occupation process	CD631QJ
*Katie St John Glew	Where do seabirds moult over winter? - A combined data logger and isoscape assignment approach	GR259GH
Camille de la Vega	Can we detect changes in Arctic ecosystems? (ARISE) - An isoscape of the Arctic Regions	HK428MD
Maritza Sepulveda	A marine top predator shows expected $\delta^{15}\text{N}$ but unexpected $\delta^{13}\text{C}$ values along a latitudinal gradient	JD327PN
*David Galván	A zooplankton $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isoscape of San Jorge Gulf, Argentina: the potential for tracking movement and habitat use of top predators over small spatial scales.	KF712SR

First author	Theme/Title	Abstract code
Fabio Costa	Geographical assignment using $\delta^{18}\text{O}$ of turquoise-fronted Parrot along the southwest-wetland to the Central savanna region in Brazil	KJ975RT
Brooke Crowley	Testing the utility of isotopes in feces for noninvasively studying the spatial ecology of big cats	KR873PL
Tegan Carpenter-Kling	Using an agent-based movement model to test different drivers which lead to the $\delta^{13}\text{C}$ tissue values of a seabird	QH852RQ
Jason Newton	A UK/Ireland insect isoscape	QM651KN
Eugenia Gayo	Baseline isoscapes for the western Andean region (18°-22°S)	SR826SF
<u>Isotope ecology from individuals to communities B</u>		
Ramiro Riquelme-Bugueno	Isotopic changes in the euphausiid <i>Stylocheiron</i> sp. in the eastern South Pacific	FR847CG
*Thibault Androuin	The dark side of soft tissue: non-expected inorganic carbonates in the invasive slipper limpet <i>Crepidula fornicata</i> and implications for stable isotope interpretations	FF119LN
* Karina González	Geographic variation in trophic position and the contribution of basal resources fuelling loco <i>Concholepas concholepas</i> , a Chilean keystone gastropod.	GS437CS
*Meica Valdivia	Aspects of trophic ecology of odontocetes species from Uruguay	GD992GB
Rodrigo Bastos	The isotopic niche overlap and segregation of two snappers (Pisces: Lutjanidae) in a tropical seascape of mangroves and coral reefs.	GL442GQ
Mickael Jacquier	"Chicken-eating" foxes: isotopic evidence of individual specialisation in a rural population of red fox	GP321PC
*Vinicius Pompermaier	Isotope niche of active soil insects as a proxy of vegetation structural complexity in neotropical savanna landscapes	GP893MB
Nicolas Sturaro	Trophic plasticity of scleractinian corals under contrasted environmental conditions: evidence from stable isotope analysis	HC337KM
Christopher Bird	A global perspective on the trophic geography of sharks	HD264PD
*Joseph Julca	Comparison of the trophic ecology between the shortfin mako <i>Isurus oxyrinchus</i> and the blue shark <i>Prionace glauca</i> , in front of the Southeastern Pacific waters	HL136RC
*Cristian Durante	Trophic niche and habitat use of two sympatric endemic dolphin species from Patagonia, Argentina.	JS218MS
Loïc Michel	Towards a global, freely available database of stable isotope ratios in foundation species from deep-sea hydrothermal vents and cold seeps.	KQ588FS
Rocío Mariano-Jelicich	Trophic relationships in a seabird assemblage associated with fisheries at the Patagonian Continental Shelf.	MT398FT
<u>Microbial isotope ecology</u>		

First author	Theme/Title	Abstract code
Felipe Docmac	Using POM stable isotope values to characterise upwelling effects on variation of coastal microbial communities.	BF873FH
Lise Alonso	Potential dissemination of microorganisms by invertebrates: is the trophic activity of <i>Collembola</i> responsible for microbial stain dissemination in Lascaux Cave (SW France)?	BK672RJ
<u>New methods and models in isotope ecology</u>		
*Emma A. Elliott Smith	Characterizing energy flow in nearshore ecosystems using amino acid $\delta^{13}\text{C}$ analysis.	RS965SN
<u>Physiology and biochemistry</u>		
Ming-Tsung Chung	Field metabolic rates of teleost fishes are recorded in otolith carbonate.	PP197MK
Eva Darenova	Effect of drought on grassland CO ₂ efflux and its $\delta^{13}\text{C}$.	QC194FQ
<u>Plant isotope ecology</u>		
Alejandro Roig Fidel	Towards the identification of past atmospheric conditions through a high-resolution $\delta^{13}\text{C}$ tree-ring record for the last 400 years in Patagonia.	BB168HP
* Laura Skates	How carnivorous are carnivorous plants? Investigating reliance on heterotrophy using natural abundance stable isotope techniques.	HG788TH
Julieta Gabriela Arco	Variations in the intrinsic water-use efficiency of <i>Araucaria araucana</i> trees under a present climate change scenario: tree age and site conditions effects.	JR819PM
*Philipp Giesemann	Hidden robbery: A new multi-element stable isotope natural abundance approach discloses organic carbon-gain effectiveness of C ₃ -hemiparasites from C ₃ -host plants.	NQ715TK
Xinhua He	Presence of adjacent grasses enhances while $^{14}\text{NH}_4^+$ –addition to receiver-pines reduces ^{15}N -movement between paired-pine saplings.	MK792GN

Poster session 3. Thursday 2 August 19:00 — 21:00. Location Main Hall, Floor -1.

First author	Theme/Title	Abstract code
	<u>Isotope ecology from individuals to communities C</u>	
Kirsteen MacKenzie	Isotopic characterisation of an inshore tropical pelagic ecosystem.	CR748MP
Sebastien Lefebvre	Benthic-pelagic couplings as key determinants of food web structure along environmental gradients.	FB547HS
Meike Koester	The invasive aquatic <i>Dikerogammarus villosus</i> - a dangerous killer or an opportunistic omnivore?	LF822TG
*Daniel Lippi	Trophic overlap and isotopic niche breadth of the mutton snapper (<i>Lutjanus analis</i>) along a Northeastern Brazilian mangrove-seagrass-coral reef continuum.	HT337KN
Camille de la Vega	Seasonal Variation of the harbour seal diet from the Wadden Sea, in relation to prey availability.	JH715QD
*Ilia Cari	Benthic trophic structure of a glacial fjord (Northern Patagonia, Chile): spatial variability of isotopic niche.	JK438GJ
Blanca Estela Molina-Burgos	A decade of diet analysis: dietary shifts of the Southern hake and the Patagonian grenadier inferred by stable isotopes.	JR581DL
Rene Gergs	How to implement stable isotope analyses into ecotoxicological risk assessment of chemicals using aquatic mesocosm experiments?	KB576LJ
Philip Riekenberg	A trophic baseline for the Wadden Sea: Examination of the contributing pathways leading to widespread enrichment of basal resources.	KG165GK
Pablo Pérez	Characterising trophic ecology and evidence for stock structure in the punctuated snake-eel (<i>Ophichthus remiger</i>) using analysis of stable isotopes, fatty acids and metal concentrations.	DK352DR
*Carlos Canales	Isotopic niche overlap of predators with high trophic levels off the coast of Chile.	LG698CG
Javier Ciancio	Isotopic niche plasticity in a marine top predator.	LG822PB
Andrius Garbaras	Evaluating invertebrate grazer reliance on seagrass (<i>Zostera</i> sp.) or filamentous algae in seagrass meadows in different state of deterioration.	LK379HS
Lydie Couturier	Global-scale analysis of trophic interactions in co-occurring tropical tuna using stable isotope analyses.	LR662GH
*Pedro Gatts	Isotopic trophic guild structure of demersal fishes in Campos Basin, northern coast of Rio de Janeiro, Brazil.	MB866MB
*Manuela Funes	Reef fishes' trophodynamic between trawled and non-trawled environments.	MC239NC

First author	Theme/Title	Abstract code
Sharon Herzka	Is C and N isotope turnover of amino acids a function of dietary protein and protein to energy ratios in marine fishes?	MF476TR
Martha Yossa	Carbon source for cachama blanca in farmponds in Orinoco region.	MP465NB
Martha Yossa	Carbon source for coporo llanero <i>Prochilodus mariae</i> in farmponds.	QB879CQ
*Bello Shirly	Diet evaluation of <i>Demochelys coriacea</i> with stable isotopes in the Colombian Caribbean.	QQ267RP
*Clarissa Teixeira	Isotopic niche comparison among three coastal cetaceans from southern Brazil.	NN336TF
Camilla Liénart	Stable isotope analyses of archived blue mussels from long-term environmental monitoring programs in the Baltic Sea.	NQ469TR
* Germán Zapata	Diel changes in the structure and isotopic diversity of coral-reef invertebrates at Easter Island.	PJ883RS
Florencia Botto	Ontogenetic change of trophic niches by the argentine hake (<i>Merluccius hubbsi</i>) evaluated with stable isotopes.	QF769MG
* Audrey Rowe	Estimates of primary production sources to Arctic bivalves using amino acid stable carbon isotope fingerprinting.	QK698HH
* Evelin Quilarque	Trophic niche of three bird species in northeastern Venezuela: spatial variation in a xerophytic environment.	RM467SB
*Vasquez Sara	Evaluation of the effects of kelp harvesting on trophic ecology of redspotted catshark <i>Schroederichthys chilensis</i> (Guichenot, 1848).	RS291GM
Lukáš Veselý	Effect of wastewater on stream food web.	TB763RJ
Gustavo Alves	Resource partitioning underlies the coexistence of two sympatric cichlids in a Neotropical floodplain.	TJ186LL
*Charles-André Timmerman	A multi-tissue approach for a better understanding of the ecology of commercial fish species.	TJ485DD
Juliana Ribeiro	Isotopic niche of small mammals from a neotropical savanna.	TJ761KN
* Robyn Thomas	The historic foraging ecology of declining tufted puffin (<i>Fratercula cirrhata</i>) populations in Washington and Oregon, USA.	TS375TN
New methods and models in isotope ecology		
*Hichem Chenaker	Oxygen and hydrogen isotope geochemistry of thermal springs in the northern part of eastern Algeria.	CH511MB

First author	Theme/Title	Abstract code
*Matias Ledesma	Trophic position in two sympatric amphipods determined from nitrogen isotopic composition of amino acids.	DN936LT
Kevin Healy	Comparing statistical methods for the estimation of trophic enrichment factors.	FG396LF
*Sabina Llamazares Vegh	Lipid corrections in carbon and nitrogen stable isotope analyses in freshwater fishes of the Paraná river, Argentina.	GS988PC
Lixin Wang	Evapotranspiration partitioning using isotope-based approaches	HH882PH
Chris Yarnes	Calibration, error estimation, and quality assurance of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ measurements from individual amino acids.	KK891NH
* Pierre-Yves Hervann	Ecodiet: a bayesian model to integrate data from the literature, stomach contents and isotopes to improve diet estimates.	KL915ND
Andrew Doll	Temporal records of diet diversity dynamics in individual adult female Steller sea lion (<i>Eumetopias jubatus</i>) vibrissae.	PF393SM
Julie Brown	Method development and applications of N_2 and N_2O measurements in water and gas samples on a GasBench II.	TC315MQ

ISOECOL 2018 WORKSHOPS:

During recent IsoEcol meetings, there has been a gradual increase in the number of workshops held in the weekends prior and following the conference. These workshops have been used to provide training in new methods and ideas, and to allow researchers active in a certain new area to compare notes and discuss future directions. They are extremely valuable as they take advantage of the rare opportunity to get large numbers of isotope ecologists in one location and also the presence of scientists at different career stages, allowing interactions between those leading in a particular field and those who wish to learn more about a particular subject.

At IsoEcol 2018 we have six workshops held over the weekend before the meeting (28-29 July), in the evening of and on the Saturday after the conference. **These are limited to delegates who have previously registered and are fully booked.** Please do not attend if you have not registered.

Workshop 1: Introduction to Bayesian statistics for stable isotope ecologists

Contributors: Andrew Jackson & Claudio Quezada-Romegialli

Date: Saturday 28 July 2018 10:00 - 16:00 Room 205, Floor 2, Tower A Number = 60

Abstract: This workshop will assume no prior knowledge (no pun intended) of Bayesian statistics. We will work through the basic theory of this approach using both conceptual and simple mathematical models. We will then extend our skills developing simple computational models to fit univariate normal models to data using both analytical solutions and simulation approaches using the JAGS software run through R. We will then move on to fitting more complex models such as simple linear models and bivariate data as an introduction to working with ellipses such as those fitted using SIBER. We will conclude by using mixing models MixSIAR and SIMMR and the ellipse and convex hull models in SIBER to test specific hypotheses and learn how to report our results. Attendees should have some familiarity with R and be comfortable fitting and interpreting general linear models using frequentist or likelihood approaches. Attendees do not necessarily have to have used Bayesian methods previously, but those with prior experience may still wish to attend to explore these methods in more depth. A full list of software and packages required will be provided closer to the date.

Workshop 2: ORIGIN: Origin Inference from Geospatial Isotope Networks – software and tools associated with a cyberinfrastructure for building and using isoscapes to estimate geographic origins of tissues

Contributors: Mike Wunder, Gabe Bowen & Hannah Vander Zanden

Sunday 29 July 2018 10:00 - 17:30 Room 726, Floor 7, Tower C Number = 45

Abstract: This workshop will introduce participants to new developments in the isotope-based toolbox for estimating spatially-explicit probabilities of origin for organic materials. By way of introduction, we will begin with an overview of research and management problems and accompanying conceptual frameworks for this type of isotope data analysis. This will be followed by an outline of the existing and planned infrastructure that provides access to environmental isotope data and models supporting the construction of isoscapes. Next, we introduce a newly introduced and rapidly developing R package that interacts with the isoscape infrastructure to build models for estimating geographic origins of sample data. Finally, we will offer a small range of example problems for attendees to work through in order to gain hands-on experience with the methods. Participants should plan to bring their own laptops and be prepared to download data and software during the workshop. Where relevant, participants are also invited to bring their own data for use and/or consultation toward the end of the workshop. We would also like to reserve some time for a round-table forum to discuss approaches that attendees have taken in their own work, and to solicit input on potential additional features that would better address the needs of the broader research community.

Workshop 3: Stable isotopes in invasive species ecology (sponsored by Millennium Nucleus INVASAL).

Contributors: Jonathan Grey & Chris Harrod

Tuesday 31 July 2018 18:45 - 20:30 Room 725, Floor 7, Tower C Number = 30

Abstract: Stable isotope analysis has become a standard tool in the invasion ecologist toolkit. We (Prof Jon Grey & Prof. Chris Harrod) are isotope ecologists using the technique to understand species (and their impacts) in both the northern and southern hemispheres. During IsoEcol 2018, we will lead a workshop aiming to gather the community together and to review the state of the art of isotope invasion ecology. Through discussion, we aim to identify what isotope invasion ecologists are doing right, what they are doing wrong, what possibilities are being missed, and what is waiting for us over the horizon in terms of challenges and opportunities. We invite interested delegates ranging from seasoned invasion ecologists or those just starting out with their studies to join us.

Workshop 4: What can iso-ecologists and iso-archaeologists learn from each other?

Contributors: Tamsin O'Connell, Francisca Santana Sagredo & Seth D. Newsome

Thursday 2 August 2018 18:45 - 20:30 Room 725, Floor 7, Tower C Number = 30

Abstract: Ecologists and archaeologists have both embraced isotopic analyses for over 40 years. Each group is asking similar questions about the individuals and populations they are studying – who is from where and what did they eat? But what does the addition of time depth mean for isotopic studies? From the nature of the available material to the scope of sampling possibilities, time has a big effect. This workshop aims at bringing together those dealing in isotopic analyses in the present and the past to discuss strengths and weaknesses, challenges, and potential opportunities. Specific topics will include: (1) the types and number of samples needed to rigorously address questions, (2) the use of controlled experiments to interpret patterns in ancient data, (3) techniques and statistical programs used to analyse data, and (4) how archaeological data can be used to better inform modern conservation and management of threatened/endangered species or key ecosystems (e.g. by providing baseline values prior to anthropogenic change). We hope that two communities (archaeology and ecology), which do not engage as much as they probably should, can learn from each other. The workshop will be held in the latter half of the conference, so we can draw out issues that have been raised during presentations and discussions during IsoEcol.

Workshop 5: Approaches to improve the reproducibility of amino acid stable isotope analyses

Contributors: Diane O'Brien, Pam Shaw, Chris Yarnes, Seth Newsome, Tamsin O'Connell

Date: Saturday 4 August 2018 13:00 - 18:00 Room 725, Floor 7, Tower C Number = 30

Abstract: This workshop will introduce participants to some approaches for monitoring, minimizing, and correcting error in analyses of amino acid stable isotope ratios by GC-C-IRMS. We will begin with an overview of how and why such corrections are done, particularly for the measurement of amino acid carbon isotope ratios, and some limitations of existing approaches. Dr Pamela Shaw, a biostatistician at UPenn will present a statistical approach to modelling measurement error in amino acid analysis, using internal (co-injected) and external (mixed amino acid) standards. She will demonstrate how such models can be used to correct for error using R (please bring a laptop with R installed for this component of the workshop). Dr Chris Yarnes from UC Davis will discuss referencing strategies, quality assurance, and other topics relating to improving the reproducibility of amino acid stable isotope measurements over time within and across labs. Dr Seth Newsome from the U of New Mexico will lead a discussion of the pros and cons of different derivatization methods (GC-C-IRMS), measurement approaches (GC vs. HPLC), and instrumentation. We hope to stimulate discussion and brainstorming of best practices for future research via an open mic question/answer session.

Workshop 6: Simulation modelling in isotope ecology

Contributor: Clive Trueman

Date: Saturday 4 August 2018 13:00 - 18:00 Room 726, Floor 7, Tower C Number = 50

Abstract: Variations in stable isotope compositions of C, N, S, O, Sr and H have provided a powerful toolbox to explore aspects of trophic, physiological and spatial ecology. The isotopic compositions of animal tissues are, however, influenced by a wide suite of variables including spatial and temporal variation in the isotopic composition of external sources, physiological influences on tissue-diet fractionation, movement patterns and diet variability. It is extremely challenging to understand the influence of these multiple, coincident sources of variance on isotopic compositions, particularly as we commonly do not know the extent of isotopic variability associated with many potential influencing variables. But if we want to draw meaningful and robust inferences from isotopic data, we should attempt to explore how sensitive our isotopic metrics may be to different sources of variance. Simulation modelling provides a framework for investigating the possible isotopic expression of complex interactions of incompletely understood processes. Building simple toy models to simulate isotopic compositions in animal tissues has two benefits: firstly, constructing models forces us to identify and attempt to quantify sources of isotopic variance and our level of knowledge inherent in a system under study (often a sobering process), and secondly, having constructed a model, we can use it to better understand our real-world data.

In this workshop we will initially discuss some of the opportunities and challenges associated with building simple simulation models, but the main aim of the workshop will be to use existing models developed by workshop leaders to run simulations for a system or topic that we all workshop attendees will identify and agree on prior to IsoEcol. We will provide basic models simulating temporal and spatial variation in isotopic sources across geographic areas, physiological models exploring isotopic fractionation through the body and individual (agent)-based models simulating animal interactions with the environment. Coupling these models gives us a framework for exploring isotopic variability and pattern in individuals and populations.

IMPORTANT – we are isotope ecologists, not modellers. We develop models that are good enough to provide an *in silico* experimental framework – but we're not trying to provide accurate behavioural or physiological representations. This allows us to use quite simple model approaches, as long as we don't forget that models are not real... We work in R, and to get the most out of this workshop, you will probably need a basic working familiarity with R coding - but nothing more.

ABSTRACTS



PLENARY MONDAY 30 JULY 2018 10:00 - 11:00.

Stable isotope ratios as biomarkers of diet in human health research.

Diane M. O'Brien

Institute of Arctic Biology and the Department of Biology and Wildlife, University of Alaska Fairbanks, USA.

Stable isotope ratios have a long history as tools for evaluating diet in anthropology and animal ecology, but have been little used in modern human populations. Nutritional epidemiology has a pressing need for objective biomarkers of dietary intake, as self-reported methods of dietary assessment have significant error and bias, leading to uncertainty in measured relationships between diet and health/disease. Thus, there is great potential for stable isotopes to provide tools for use in nutrition-related health research. Over the last 10 years my lab has been working on evaluating natural abundance stable isotope tools for applications in nutritional epidemiology, starting with an Alaska Native population. The nitrogen isotope ratio was particularly informative as a biomarker of traditional dietary intake for Yup'ik people, given the high levels of fish and marine mammals in their traditional diet. We have used the nitrogen isotope ratio to determine relationships between traditional food intake and disease risk and protective factors, and to show how traditional food intake has changed over time using archived biospecimens. We also have a strong interest in using the carbon isotope ratio to study added sugar intake (as most US added sugars are C4); however, specificity is a major challenge as the carbon isotope ratio is also elevated in corn-fed meats and other corn-derived foods. In this regard, nutritional epidemiologists and animal ecologists face similar challenges, as both often need better specificity than is provided by bulk isotope ratios. One approach we have used to improve specificity is to calibrate predictive models of diet based on multiple isotopes. Another is to use compound-specific measurements, where specific molecules can be metabolically linked to foods of interest. We have found that the carbon isotope ratio of the amino acid alanine, which is one metabolic step away from pyruvate, is a specific biomarker for sugar-sweetened beverage (SSB) intake. Currently we are working with specimens from a long-term (14 week) controlled human feeding study varying fish, meat and added sugar/SSB intake, to evaluate isotopic turnover, bulk, amino acid and fatty acid biomarkers in blood, hair and adipose tissue

BG417CT

New methods and models in isotope ecology I

Oral presentation Monday 30 July 2018

Preservation methodology and stable isotope composition in sea stars: Can museum collections be useful for trophic ecology studies?

Baptiste Le Bourg¹, Gilles Lepoint¹, Pierre Balthasart², Loïc N. Michel^{3,4}

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Museum samples potentially represent a valuable source of samples for food web studies. They can notably help to fill gaps in our knowledge of ecology of species coming from data-poor regions or ecosystems. Moreover, old samples, which have been collected during period when environmental conditions were different from today, could be used to study long-term temporal trends in the trophic ecology of organisms. However, in most cases, museum samples were not initially collected for stable isotope analyses (SIA) and they are generally fixed in preservative solutions. Because these preservation methods may alter stable isotope ratios, their effects should be quantified to determine whether old museum samples are indeed suitable for this technique. This has not been assessed in sea stars so far. Here, we investigated long-term effects (up to two years) of common preservation methods (freezing, 99% ethanol, 4% formaldehyde) on $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of the Atlantic sea star species *Marthasterias glacialis* and the Southern Ocean sea star *Labidiaster annulatus*. In both cases, the influence of preservative fluids was investigated not only by comparing mean isotopic values of fresh and preserved samples, but also by comparing key isotopic niche parameters (standard ellipse area SEAC and SEAB, niche overlap) to check how preservative fluids could impact those increasingly used ecological metrics. Formaldehyde quickly affected sea star $\delta^{13}\text{C}$ values, resulting in strong reduction of the overlap between the isotopic niche of the fresh samples and those of the preserved samples. However, after being altered, the mean $\delta^{13}\text{C}$ value remained stable over time, suggesting that a correction factor could be used regardless of preservation time. Ethanol preservation did not affect significantly sea star $\delta^{13}\text{C}$. Neither ethanol nor formaldehyde solutions had consistent effect on sea star $\delta^{15}\text{N}$. Changes of isotopic niche size across time in *Marthasterias glacialis* were observed, but were usually not significant. These results suggest that sea star samples stored for long periods in ethanol can be used for SIA. More caution is advised when dealing with formaldehyde-preserved specimens, whose $\delta^{13}\text{C}$ should be corrected before data analysis.

GN842TF

New methods and models in isotope ecology I

Oral presentation Monday 30 July 2018

Do isotopic spaces represent food webs properties? A theoretical framework seeking for empirical data.

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Isotopic analyses are exponentially used to assess the structure of food webs and a series of isotopic functional metrics have been suggested in the last decade to characterize this structure. These indices are based on the foundational assumption that proximity in the isotopic space informs on trophic similarity and/or trophic interactions between species. While it has been recognized for long that this simplifying assumption should be used with caution, no formal evaluation has been performed to date. We tackled this question using an *in silico* modeling approach. Using a niche model, we simulated a large number (15 000) of food webs with varying characteristics to assess (i) whether isotopic distance is a good proxy of trophic dissimilarity; (ii) whether isotopic functional indices are good proxies of trophic functional properties; and (iii) how the quality of these two proxies depend on various species and food web properties. Results evidenced that grasping subtle changes in food webs properties with community-wide isotopic metrics is illusionary. Interestingly results also suggest that the reliability of the isotopic mapping of consumers to characterize trophic properties decreases with their number of potential prey species (high complexity), but increases with their number of realized prey species (large connectance). Consequently, isotopic reliability decreases in species-rich food webs with low connectance, large vertical diversity and large incidence of omnivory. But does that sound like actual species communities? We are here aiming at analyzing food webs database (globalwebdb.com) by the prism of our theoretical results. Based on « canonical » characteristics defined above (richness, connectance, omnivory etc.), we are building a decision tree to help isotopic ecologists evaluating the confidence using isotopic metrics to estimate the food web properties and ultimately system functioning. The idea is to evaluate how and when isotopic information should be used in combination with complementary information. Additionally, this framework should also be seen as a call to challenge isotopic metrics using *in silico* modelling approaches with other food web modelling approaches - either theoretical or finalized ones - as a new field of investigation would emerge.

Groupe de Recherche en Ecologie Trophique (CNRS GdR 3716) and the Total Foundation

JP719KM

New methods and models in isotope ecology I

Oral presentation Monday 30 July 2018

The new Titanium Method: a simple, one-step reduction of aqueous NO_3^- to N_2O for IRMS or Laser-based analysis of $\delta^{15}\text{N}$, $\delta^{18}\text{O}$, and $\delta^{17}\text{O}$

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The nitrogen and triple oxygen ($\delta^{15}\text{N}$, $\delta^{18}\text{O}$, $\delta^{17}\text{O}$) isotopic compositions of NO_3^- are crucial tracers of nutrient N sources and dynamics throughout the biosphere. The prevailing sample preparative methods, like the bacterial denitrifier method or the Cd-Azide method, utilize laborious multi-step conversion methods (and in the latter case highly toxic chemicals) to reduce nitrate to N_2O for stable N and O isotopic analyses by isotope ratio mass spectrometry. As a result, only a few specialized laboratories undertake these complex assays. In both cases, $\delta^{17}\text{O}$ cannot be obtained using IRMS systems due to isobaric interferences between ^{15}N and ^{17}O in N_2O unless a further on-line conversion to N_2 and O_2 is carried out. Here we present a new, simple, one-step chemical conversion method that employs an off-the-shelf titanium (III) reagent to reduce nitrate to N_2O in IRMS-ready Exetainer or laser vials. Sample preparation takes only a few minutes, followed by a passive 24 h reaction producing N_2O gas which partitions into the vial headspace. Results using IRMS and Laser spectrometers show that this N_2O method produces excellent results comparable to the denitrifier and Cd-azide methods. Long-term testing (6 months) shows that accurate and reproducible results are achievable. Typical analytical uncertainties for nitrate reference materials (i.e. USGS32, USGS34, IAEA NO3) are ± 0.2 ‰ for $\delta^{15}\text{N}$, and ± 0.3 ‰ for $\delta^{18}\text{O}$ using IRMS. For the laser-based N_2O isotope analyses the results are similar, and for direct measurement of N_2^{17}O average uncertainties for $\delta^{17}\text{O}$ are ± 0.9 ‰, without any need for isobaric corrections. The key advantage of the new titanium method is its simplicity, low cost, speed, and no need for toxic chemicals or bacterial cultures. The method can be easily implemented by new laboratories (i.e. using Gas bench or Trace Gas Multiflow), or directly substituted into laboratories currently using multi-step bacterial or Cd methods. The ease of this new method will greatly facilitate the use of isotopes in studies of nutrient dynamics in a large-range of ecosystems.

JT236HR

New methods and models in isotope ecology I

Oral presentation Monday 30 July 2018

Nano-scale secondary ion mass spectrometry (nano-SIMS) images can differentiate soil organo-mineral complexes and associated carbon preservation

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The submicron information about *in situ* mechanisms of fertilization practices affecting organo-mineral complexes and associated carbon (C) preservation is limited. Recently, a novel imaging facility, nano-scale secondary ion mass spectrometry (Nano-SIMS), is capable of the concurrently quantitatively high spatial resolution imaging of five stable isotopes (e.g., ²H/¹H, ¹³C/¹²C, ¹⁵N/¹⁴N, ¹⁸O/¹⁶O, ³⁴S/³²S, etc.) with high sensitivity at ≥50 nm metric and ppm atom scales. Nano-SIMS analyses are particularly powerful when combining with ¹³C- and ¹⁵N-labelled amino acids, which can bound to their amino, carboxyl or both groups depending on their size. The quantitative of molecular and isotopic patterns of inorganic and/or organic C and N source could be hence imaged and detected. We applied Nano-SIMS, X-ray photoelectron spectroscopy and X-ray absorption fine structure spectroscopy to examine submicron effects of 24-year long-term inorganic (NPK: nitrogen, phosphorus & potassium) vs. organic (M: manure; and NPKM) fertilization on associations of organic and mineral components in a red soil in south China. Results showed that organic amendments had significantly increased the mineral availability, particularly in the short-range-ordered (SRO) phases. Nano-SIMS images provided direct evidence that citric acid, a major component of root exudates, promoted the formation of SRO minerals, which acted as "nuclei" for C retention, and that the submicron elemental distribution and spatial heterogeneity in the soil colloids and the ratios of ¹²C-/²⁷Al¹⁶O- and ¹²C-/⁵⁶Fe¹⁶O- were greater under NPKM or M than under NPK. The C-binding loadings of Al and Fe minerals in colloids at submicron scales, and the concentrations of highly reactive Al and Fe minerals, were greatly enhanced under NPKM or M than under NPK. Our submicron-scale findings suggest that both the reactive mineral species and their associations with C are differentially affected by 24-year inorganic and organic fertilization.

National Natural Science Foundation of China (41371248 and 41371299), Chongqing 100 Talents Plan (2015) and National Key Research and Development Project of China (2016YFD0200104).

KT184TD

New methods and models in isotope ecology I

Oral presentation Monday 30 July 2018

Applying the Bayesian mixing model MixSIAR to fatty acid and stable isotope data to estimate diet of Antarctic seals

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The combined use of fatty acids (FAs) and stable isotopes (SIs) has been recommended to accurately estimate diet composition. However, FA analysis has mainly been applied as a qualitative rather than a quantitative tool. Recently, efforts have concentrated on developing robust biotracer-based quantitative methods to obtain accurate estimates of diet. Bayesian mixing model approaches were originally developed using SIs; however, they can be applied to any mixing process and be easily adapted for new variables; therefore, it may be a powerful framework for estimating predator diets using other types of data, such as FAs. The purpose of this study was to apply the quantitative Bayesian mixing model MixSIAR to both FA and SI data to evaluate how these two biochemical methods can be used complementarily to infer diet. We estimated diet in three sympatric Antarctic seals: the leopard seal, *Hydrurga leptonyx*; the crabeater seal, *Lobodon carcinophaga*; and the Weddell seal, *Leptonychotes weddellii*; using FAs from their blubber and SIs from their whiskers. Samples from a total of 54 seals were collected during the austral summer of 2015, off the Western Antarctic Peninsula. Overall, FA- and SI-based predictions were similar. Using both techniques, crabeater seals were found to consume almost exclusively krill, leopard seals were also estimated to feed mainly on krill, and Weddell seals diet was inferred to be dominated by fish. Due to FAs having more variables than SIs, it was possible to discriminate between species. For example, we used 3 fish species as potential prey of Weddell seals; the FA-based analysis determined that the notothenid *Pleurogramma antarcticum* was the main prey followed by *Notothenia coriiceps*, whereas the myctophid fish *Electrona antarctica* was virtually absent. However, with SI data fish species had very similar isotopic values and hence had to be combined into a single group, making it difficult to estimate diet to species level. Similarly, FA-based analysis estimated that crabeater seals not only consume *Euphausia superba* but also other krill species. We recommend the use of MixSIAR for FA data and encourage the use of both FA and SI analyses as complementary methods to obtain better taxonomic resolution.

Australian Research Council, Scott Foundation

MC498KN

New methods and models in isotope ecology I

Oral presentation Monday 30 July 2018

Integrating Gene Expression with Stable Isotopes and other Trophic Ecology Datasets: A Conceptual and Quantitative Framework

Trevor Krabbenhoft¹, Seth D. Newsome², Corey Krabbenhoft³, Thomas Turner²

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Stable isotope approaches have opened many doors for addressing research questions and dramatically changed our understanding of the trophic ecology of organisms. Several other newer methods that may complement stable isotopes have the potential to further our understanding of energy flow in food webs. In particular, a key development is the decline in costs associated with DNA sequencing, making it feasible to conduct genome-wide gene expression studies (RNA-seq) with large numbers of samples collected from natural settings. RNA-seq affords novel information on expression of digestive enzymes and other genes, helping to elucidate what organisms are actively digesting – and thus bridge a key gap between gut contents (diet) and resource assimilation into tissues (isotopes). We briefly outline the role RNA-seq might play complementing isotopes in trophic ecology studies and discuss the biological interpretation of these data types. We provide an example dataset from fishes in the Rio Grande that demonstrates the promise this approach has for expanding our understanding species interactions and energy flow in food webs. Despite broad overlap in isotopic niche space for fishes in this system, RNA-seq data illustrate significant differences in expression of key digestive enzymes (e.g., amylase, chitinase). This suggests that there might be fine-scale resource partitioning, based on what fish are actively digesting, and that new insight might be gained by adopting this multi-level approach (i.e., digestion and assimilation). An important challenge that remains is how to integrate the analysis of these datasets – isotopes, diet, gene expression – in a common analytical framework. We discuss preliminary ideas to this end, focusing on partial least squares and adapting methods originally developed for isotope data, such as dispersion metrics (e.g., ellipse areas), multivariate analyses, and randomization tests. How well these methods will perform on RNA-seq data remains to be seen. Nonetheless, the ongoing development of new approaches continues to expand the possibilities toward fully integrated trophic ecology studies across multiple levels of biological organization, from single molecules (DNA or amino acids) to entire ecosystems.

BD235BG

Isotope ecology from individuals to communities I

Oral presentation Monday 30 July 2018

Compound-specific isotope analysis of amino acids indicates human dietary exposures in a clinical feeding study

Jessica J Johnson¹, Jonathan Krakoff², Susanne B Votruba², Pamela A Shaw³, Eric Oh³, Matthew J Wooller⁴, Diane M. O'Brien¹

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(2) Obesity and Diabetes Clinical Research Section, Phoenix Epidemiology and Clinical Research Branch, USA

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Stable isotope ratios (SIR), long acknowledged as useful dietary biomarkers in ecological systems, have potential as human dietary biomarkers for biomedical research. Objective, unbiased biomarkers of human dietary intake are badly needed due to the error and bias associated with self-report methods of dietary assessment. Previous studies have found significant correlations between human dietary exposures and bulk SIRs ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values). However, these biomarkers may not be sufficiently specific; for example, bulk $\delta^{13}\text{C}$ values may confound intakes of meat and added sugars. This calls for a compound-specific approach. In this study, we measured plasma and red blood cell (RBC) amino acid $\delta^{13}\text{C}$ values in human subjects participating in an on-going, long-term (10-14 weeks), fully in-patient feeding study. Since 2011, twenty-eight male participants have completed the feeding protocol. Each participant was randomly assigned to one of eight diets, which manipulated the intakes (presence/absence) of fish, meat and sugar-sweetened beverages in all possible combinations while maintaining a macronutrient distribution of 50% carbohydrate, 30% fat, and 20% protein at a weight-maintenance level. Blood samples were collected biweekly through the end of the study. Plasma and RBC $\delta^{13}\text{C}$ -amino acid values were measured using compound-specific isotope analysis, via n-acetyl methyl ester derivatization and gas chromatography-combustion-isotope ratio mass spectrometry. We will present results on the associations between the $\delta^{13}\text{C}$ values of essential and non-essential amino acids and the dietary intakes of fish, meat and sugar-sweetened beverages. Preliminary results show significantly higher plasma $\delta^{13}\text{C}$ -alanine values in participants who consumed sugar-sweetened beverages versus those who did not. We also saw significantly increased plasma $\delta^{13}\text{C}$ values in essential amino acids (valine, leucine, isoleucine) with meat consumption. This study aims to find consistent responses in the $\delta^{13}\text{C}$ -amino acid values of humans exposed to the same nutritional intake, irrespective of the absolute SIR values in the diet or the discrimination between diet and tissue. This will help determine the suitability of these biomarkers in clinical and epidemiological studies and establish new ways to study large-scale trends in the diets of human populations.

This study is funded by the National Institutes of Health, grant: NIH R01 DK109946 Molecular Stable Isotope Profiles of Dietary Exposure.

BL192BS

Using stable carbon and hydrogen isotope analyses of lipids and breath CO₂ to infer sources of fueling in migratory birds and insects.

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Lipids are a fundamental fuel for migration and are also stored to allow periods of fasting. Knowing where and when lipids are formed and stored in migratory animals provides important information in understanding physiological life history strategies. Bulk lipids contain carbon and hydrogen and the stable isotopic compositions of such lipids potentially can be related to provenance and/or biome characteristics. We conducted captive experiments on migratory monarch butterflies (*Danaus plexippus*) and the true armyworm (*Mythinma unipuncta*) to examine patterns of isotopic discrimination between diet (C,H) and drinking water (H) and evaluated the degree to which forensic information could be gained at continental scales. We also revisited the use of stable carbon isotope analyses of breath CO₂ as a means of elucidating isotopic (C) values of stored lipids in migratory birds (*Catharus ustulatus* and *Setophaga caerulescens*) using both captive and wild (migrating) individuals. We determined that spatial information can be gleaned from isotopic analyses of lipids in wild animals, but the degree of resolution is inferior to demonstrated results obtained for animal keratins and chitins. Nonetheless, we argue that isotopic variance in lipids and breath at the population level can be used to infer the use of local vs distant fuel sources and the degree to which migrant populations adapt individual vs population level strategies of fueling.

BR957JM

Isotope ecology from individuals to communities I

Oral presentation Monday 30 July 2018

Isotopic outliers: detecting functional rarity

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Since the introduction of stable isotope analysis in trophic ecology, main interest focused on the reconstruction of general patterns of food webs such as the number of trophic levels and the degree of omnivory. Nevertheless, any extended study of natural communities reveals more or less numerous specimens or species that do not fit expected isotopic patterns, being either extremely enriched or extremely depleted in certain isotopes. Single specimens having extreme isotopic composition are often discarded as outliers, although unusual delta values may reflect trophic stress, severe parasite infestation and other conditions of ecological relevance. At the species level, isotopic rarity clearly reflects unusual physiological pathways, trophic links or other ecological traits that often remain undetected when using traditional methodologies. Here I argue that stable isotope analysis is a powerful tool in a newly emerged field of the ecology of outliers (Chase 2013; Violle et al. 2017). The work is based on the analysis of published data on the stable isotope composition of terrestrial animals supplemented by original data on soil communities. The frequency of the isotopic outliers is relatively high. Very often their unique position in food webs is not related to distinctive taxonomic identity or low abundance. Moreover, some very common and seemingly well-studied species such as red squirrel (*Sciurus vulgaris*) or extinct woolly mammoth (*Mammuthus primigenius*) seem to be isotopic outliers. Further examples include Geoglossaceae fungi, Neanuridae springtails, certain Nasutitermitinae, etc. I discuss possible mechanisms leading to unusual isotopic signatures of fungi and animals and suggest a conceptual framework for detecting and quantifying isotopic rarity of species that reflects different facets of ecological uniqueness manifested in physiology, trophic links and the use of specific microhabitats.

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Food webs in subterranean ecosystem: is omnivory a necessity in extreme low-productivity environment?

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Groundwater ecosystems are characterized by the absence of photosynthetic primary productivity and rely on the sporadic inputs of organic matter resources originating from surface waters, with the exception of a few chemoautotrophic systems. Therefore, these subterranean systems are among the most energy-limited environments on Earth.

Because of the scarcity, and the temporal and spatial variations of food sources, subterranean organisms have been classified as generalist feeders using a wide range of resources to satisfy their energetic requirements. Groundwater food-webs are therefore considered to rely on a large variety of basal resources, consisting of fine and coarse leaf and wood debris, and sedimentary biofilm. At higher trophic levels, food-webs have been considered as "truncated" because of the low occurrence of obligate groundwater predators in subterranean ecosystems. Most predators are thought to derive their energy from exploiting basal resources in addition to consuming preys. The apparent prevalence of omnivory among predators is interpreted as an opportunistic strategy to cope with the scarcity and irregularity of resources. Predators would therefore persist by using an alternative food resource when preys get driven to very low density, and theory predicts that a strict predator population cannot persist at such low level of energy availability.

Nevertheless, the prevalence of omnivory in subterranean environments has not been proven because of difficulties to sample hypogean streams. To fill this gap, the present study aimed to analyze the food-web structure of 10 cave rivers using ¹³C/¹²C and ¹⁵N/¹⁴N of invertebrates and basal resources to determine the extent of omnivory vs strict predator strategy in low-productivity environments. Our reconstruction of 10 cave food-webs showed that these groundwater ecosystems were mainly supported by sedimentary biofilm. Three caves exhibited only one trophic level. Stable isotope data showed the existence of strict predation in 5 caves and omnivory in 2 caves. The unexpected result that strict predator populations can persist in low productivity environments could be explained by the exceptional capacity of subterranean organisms to withstand periods of inadequate or poor nutrition sources (low metabolic rate, efficient use and restoration of body reserves, strong resistance to starvation).

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CJ139HR

Isotope ecology from individuals to communities I

Oral presentation Monday 30 July 2018

The food web consequences of a massive dieback of mangrove forest in the Gulf of Carpentaria, Australia.

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Mangrove forests support coastal fisheries through complex food web interactions and are essential for healthy coastal ecosystems, yet catastrophic climate driven loss of mangroves is anticipated. During the summer of 2015-16 a massive extent (>7000 ha) of mangroves died along ~1000 km of coastline in the Gulf of Carpentaria, Australia. This coincided with an extended period of high temperatures and dry conditions in the region. The magnitude of this mangrove dieback seems to be unprecedented. To investigate the food web consequences of the massive mangrove dieback, we undertook field investigations coupled with stable isotope analysis in the affected mangrove forest. The composition of species (e.g. crabs and gastropods) shifted from mangrove leaf-litter feeders to favour micro-algal specialists. For instance, fiddler crabs (i.e. primarily micro-algal specialists) were successful after the disturbances and significantly more abundant than leaf-litter feeders (i.e. sesamid crabs) in the dieback mangrove forest. Stable isotope analyses ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) confirm this change in resource use throughout the food-web. The massive dieback stimulated harsher environmental conditions (e.g. a severe sunlight exposure due to the reduced canopy), and changed the availability of key resources (e.g. high benthic microalgae and low leaf-litter). This mangrove die-off has therefore driven changes in species assemblages and trophodynamics. Given the importance of mangroves to coastal communities (both for food and habitat), this catastrophic dieback may consequently disturb local food webs by shifting habitat physical conditions (i.e. altered light and temperature regimes) and changing key food sources (i.e. reduced mangrove litter availability). Changes in primary consumer composition will also likely drive changes in higher trophic levels, potentially affecting the key ecosystem service that mangrove forests provide, i.e. trophic support for coastal fisheries.

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CQ278PJ

Isotope ecology from individuals to communities I

Oral presentation Monday 30 July 2018

Amino acid isotopes in penguin feathers reveal a history of climate change and historic whaling in the Antarctic Peninsula

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The Southern Ocean is in an era of extraordinary change, reflecting recent climatic warming and historic overharvesting of marine mammals, on top of longer-term natural climate variability. These disturbances may have profound effects on the sources and cycling of organic matter supporting Antarctic food webs. *Pygoscelis* penguins, which occupy a central node in Antarctic food webs, act as sensitive indicators of environmental change in the Antarctic Peninsula. Furthermore, bioarchival penguin tissues (e.g., feathers, eggshells) are well preserved in ornithographic sediments and museum collections, providing a window into past ecosystem responses to environmental change. For instance, Gentoo penguins from the Antarctic Peninsula show dramatic changes in bulk nitrogen isotope values over the last 100 years that may reflect changes in penguin trophic dynamics or biogeochemical cycling at the base of the food web. We use compound-specific stable isotope analysis of individual amino acids to disentangle these confounding variables and explore changes in food web architecture supporting penguin productivity over the past century. We found that Gentoo penguins showed a marked increase in trophic position over the last 40 years, which correspond with the return of baleen whales in the region following extensive overharvesting in the 1800s and early 1900s. Furthermore, Gentoo penguin feathers recorded a pronounced increase in source amino acid nitrogen isotope values over the last 80s, reflecting a shift in biogeochemical cycling that we hypothesize reflects climate-induced increases in productivity along coastal open water polynyas. These findings highlight the profound shifts in Antarctic food web architecture playing out over decadal to century time scales as a function of interactions between human exploitation and rapid climate change. The molecular geochemistry approaches developed here will open new doors to studying the relationships between environmental change and ecosystem response and shed new light on potential future ecosystem responses in this age of rapid climate change.

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Climate and productivity drive regime shifts in subarctic lake food webs

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Subarctic habitats are warming faster than any other biome on Earth. An extended growing season, in addition to increased temperature and nutrient availability, is changing subarctic lakes from pristine, cold, oligotrophic environments to warmer and more productive ecosystems. Deciphering the effects of these changes on the function of subarctic lake ecosystems provides valuable insights into the repercussions of climate change on carbon dynamics and the food webs supporting resident and invasive consumers and fisheries. Evidence for these effects is currently based on observations of consumer community structure, diet and foraging behaviour, but it often fails to account for indirect assimilation pathways which may act as hidden drivers of the ecological responses to climate change. To better understand how such indirect assimilation and resource coupling affects the relationship between climate, productivity and ecosystem function, we compiled carbon and nitrogen stable isotope and diet data from over 9,000 consumers to reconstruct the resource and foraging pathways which support invertebrate and fish communities in 30 subarctic lakes, spanning a temperature (+3°C), precipitation (+30%) and nutrient (+45 µg/L total phosphorus) gradient equating to projected future climate scenarios for subarctic Europe. We found that climate is a fundamental driver of energy pathways in subarctic lake food webs, causing a regime shift from benthic to pelagic resource reliance. The contribution of pelagic carbon to primary, secondary and tertiary consumers increased from 25% to 75% with increasing lake temperature. In contrast, the relative contribution of pelagic prey to the diet of fishes did not change across this gradient. In addition, the largest increases in pelagic resource assimilation were evident in benthic feeding taxa, indicating that pelagic-benthic coupling becomes increasingly important to benthic consumers following warming and associated increased productivity. As pelagic and benthic energy-based food webs have many fundamental ecological differences, the detected regime shift suggests large effects on ecosystem functioning of subarctic lakes. Our study demonstrates that integrating consumer stable isotope and diet data at a landscape level can provide unheralded insights into the ecological processes underpinning climate-driven changes in species' distributions and ecosystem functioning.

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Isotope ecology from individuals to communities I

Oral presentation Monday 30 July 2018

Detecting the "famine relief diet" through stable isotope analysis: a case study from tropical Africa

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As globalization expands, people and cultures abandon traditional ways of life, and consequently, dietary diversity is lost. Although the spread of "Western" diets is a well-known phenomenon, insufficient research has targeted the impact of famine relief programmes on local diets. In this study, we conducted carbon and nitrogen isotopic analyses on hair (n=134), nail (n=80), and breath (n=184) from five tropical African groups (El Molo, Turkana, Luhya, and Luo from Kenya; and Baka from Cameroon) with four subsistence patterns: pastoralism, hunter-gathering, agriculturalism, and lake fishing. The results indicate that the pastoralist Turkana have abandoned the traditional diet of milk and blood in favour of C₄ plants (namely maize), and that a similar shift is present among the other Kenyan groups. In fact, the Luhya presented a carbon isotopic signal that suggests a diet that is entirely based on C₄ products. In contrast, the Baka maintained an isotopic signal consistent with the traditional diet of only forest C₃ foods, but the analyses may have failed to detect any change within this C₃ diet. Development studies show that the C₄ maize has long been introduced as a famine relief food in East Africa, and that this intervention has had a substantial impact in the livelihoods of Kenyan people. For instance, as the Turkana have become increasingly dependent on such staples, they settled and abandoned their original nomadic lifestyle. Thus, this process has major health and demographic implications, making it important that dietary assessments are based on direct (e.g. isotopes) rather than indirect measures of diet (e.g. questionnaires). Whilst we should recognise the value of famine relief programmes in mitigating hunger and decreasing death rates, such programmes are sometimes unable to meet all the nutritional requirements of the targeted population and can unintentionally alter population dynamics. In conclusion, this study shows how isotopes can be used to track the dietary changes associated with development (generally) and aid programmes (particularly), although the adequacy of the analyses will depend on each context. We believe that isotopic analyses may serve as a new and independent tool with which to track and tailor long term relief efforts.

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Isotope ecology from individuals to communities I

Oral presentation Monday 30 July 2018

Trophic web overlap between southern elephant and crabeater seals

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We investigated the trophic ecology of two species of Antarctic phocids along the western Antarctica Peninsula: the southern elephant (*Mirounga leonina*) and crabeater seal (*Lobodon carcinophaga*) using stable isotope analyses (SIA). Our objectives were (1) to evaluate what trophic webs of the western Antarctica Peninsula are impacted by these species, and (2) to accurately define the trophic position (TP) of both species. Crabeater seals consistently having significant lower values for both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ than elephant seals. Despite their more restricted spatial ranges, crabeater seals showed larger variability in their isotopic values, likely a result of seasonal shifts in the composition of the coastal phytoplankton community. Using SIA of amino acids we were able to discriminate between three food webs that are impacted by crabeater and elephant seals: a coastal, intermediate and oceanic food web. As predicted, most crabeater seals occupy a coastal trophic web, whereas elephant seals are fueled by both oceanic and coastal trophic webs. Most individuals occupy similar TPs when comparing values within species (TP crabeater seal coastal = 2.12, TP elephant seal oceanic = 3.21), however, the TPs of both species of seals is similar for those individuals in the intermediate trophic web (TP crabeater seal intermediate = 2.96, TP elephant seal intermediate = 3.29), which could indicate krill consumption by elephant seals.

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Isotope ecology from individuals to communities I

Oral presentation Monday 30 July 2018

Diet as an important factor of male status in the southern elephant seal (*Mirounga leonine*).

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Within polygynous breeding systems, intra-sexual selection between males generally leads to the formation of a dominance hierarchy. There has been debate over which factors favour the establishment of social dominance. Where some studies argue that body mass is the singular determinant of social rank, others show that rather than the males' mass, it is their length. However most of these studies have been of males from terrestrial systems. In terrestrially breeding polygynous species, dominant males secure not only mating access to females, but also to areas of high value food resources. For semi-aquatic mammals, such as the southern elephant seal, social dominance does not confer access to food resources as the males fast while ashore in the breeding colonies. The males' foraging choices made at sea, prior to the breeding haul outs, reflects a male's diet prior to dominance establishment. We ask whether a male's diet, body mass and/or length conferred an advantage in attaining social dominance.

To reconstruct the diet of males of different social ranks we used bulk $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values of serum collected from sexually mature male southern elephant seals ($n=44$) during the breeding season at King George Island, within the South Shetland archipelago. To identify which factors (diet-inferred from $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values, body mass, and/or standard length) influenced male social rank, we conducted a series of mixed models and took a model selection approach. Socially dominant beachmasters had a larger body mass and significantly enriched $\delta^{15}\text{N}$ values compared to less dominant males. The significant ^{15}N enrichment ($>3.4\text{‰}$) of the dominant males, suggests that they fed on higher trophic prey. There was no difference in $\delta^{13}\text{C}$ values of the males of different ranks suggesting that both dominant and subordinate males fed in similar regions. An interaction between diet ($\delta^{15}\text{N}$) and body size (both mass and length) explained the greatest variation between males' social rank. This interaction between body mass and diet ($\delta^{15}\text{N}$) potentially infers a feedback, such that males of a larger body mass can make deeper/longer dives, gaining access to larger prey and so confers a higher energetic efficiency.

FP269RJ

Isotope ecology from individuals to communities I

Oral presentation Monday 30 July 2018

Deciphering the significance of intrapopulation variations in plant carbon isotopes

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When measuring carbon isotope ratios of wild plants under natural conditions, it is not uncommon to measure variations of 2-6 per mil within a population, even after sampling has been controlled for canopy position, leaf age, and other ecophysiological considerations that influence intra-plant variations in carbon isotope ratios. The questions become: (1) Why should so much variation exist? and (2) What are the drivers resulting in expression of such carbon isotope ratios differences? Here we evaluate population-level variations in carbon isotope ratio values of *Encelia farinosa*, one of the most common drought deciduous shrubs of the Mojave and Sonoran Deserts of North America. We show that intra-population variations in carbon isotope ratios among plants range from 4-6 per mil and that rankings in carbon isotope ratios among individual plants are maintained over time once plants have matured, even though there are acclimation-related variations associated with drought and wet periods. From long-term decadal observations, it appears that *Encelia farinosa* genotypes with more negative carbon isotope ratios are more competitive for water occur during the growing season. In contrast, it appears that genotypes with more positive carbon isotope ratios have greater survival rates during dry years or prolonged drought periods. The variations in carbon isotope ratios can be explained mechanistically in terms of the ratio of intercellular to ambient CO₂ levels and these carbon isotope ratio variations can be linked to plant carbon gain and water loss. It appears that contrasting selective drivers associated with interannual and decadal-scale variations in ENSO and PDO cycles may be contributing to maintaining genotypic variation of the physiological mechanisms that affect carbon isotope ratios within these *Encelia farinosa* populations.

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Isotope ecology from individuals to communities I

Oral presentation Monday 30 July 2018

Fish physiological responses to environmental changes revealed by otolith metabolic proxy

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Climate change impacts individual animal largely through changes to metabolic costs associated with maintenance, resource acquisition and competition. Determining individual-level field metabolic rates is therefore a major step towards ecologically-based predictions of population responses to climate change. We have shown that the isotopic composition of carbon in otolith aragonite can be used as a proxy field-based for oxygen consumption rates in Atlantic cod (*Gadus morhua*), as the otolith $\delta^{13}\text{C}$ value is a weighted average of the $\delta^{13}\text{C}$ values of water and metabolic carbon. Here we use this proxy to evaluate spatial, temporal and genetic influences on metabolic performance of Atlantic cod in natural habitats. We compare field metabolic rates between cod from the North Sea and Greenland, and from two co-occurring but genetically distinct populations in West Greenland waters (Greenlandic offshore and Icelandic offshore). We draw on historic otolith collections and compare cod sampled from 1982-1990 for the North Sea and from 1952-2016 from the Greenland populations. Atlantic cod populations differed in field metabolic rates between geographic and genetic populations, but the between-population difference changed among years. The complex relationship between experienced climate and population level metabolic rates may imply metabolic plasticity and diverse adaptive strategies between cod populations and provides a physiological perspective to explain population dynamics under changing climates. Current theory predicting the performance of fish under different climate change scenarios, typically does not take into account individual behavioural and physiological responses and adaptation, or altered metabolic costs associated with changing foraging and predation dynamics. Otolith-based measurements of individual-level field metabolic rates in wild fish populations could provide data needed to enhance ecological models and provide more accurate and precise predictions of fish population dynamics, behaviour and adaptation under a long-term environmental change.

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Adaptation of compound-specific amino acid analyses (^{13}C and ^{15}N) for analyzing the structure of soil animal food webs

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Forest soil food webs are complex and heterogeneous systems. Due to the small body size of most soil animals, cryptic habitat and complex mixtures of resources, trophic relationships are difficult to disentangle. In contrast to bulk stable isotope analyses that depend on correct estimation of the isotopic baseline, compound-specific isotope analysis (CSIA) of amino acids (AAs) may allow simultaneous identification of basal resources and trophic position. "Stable isotope fingerprinting" takes advantage of the fact that ^{13}C signatures of essential AAs differ between plants, fungi and bacteria due to different biosynthetic pathways. ^{15}N signatures of trophic and source AAs include information on isotopic baseline and allow accurate identification of the trophic position. We conducted a controlled feeding experiment in which we constructed a decomposer food chain including detritivores (Collembola) and predators (spiders) with the former raised on different basal resources including plant leaves, bacteria and fungi. We analyzed bulk and compound-specific isotope signatures of animals and resources. For the fingerprinting approach, we used isotope signatures of basal resources as endmembers to predict the biosynthetic origins of amino acids in animals. While animals with bacteria and plants as basal resource were all classified correctly, results for the fungal food chain were not as clear-cut. Nevertheless, the fingerprinting approach provided more detailed information on basal resources than bulk isotopic signatures. In Collembola, trophic position estimated by CSIA was very close to the actual trophic position, except for Collembola reared on leaf litter, where it was higher than expected. Trophic position of spiders estimated by CSIA was lower than expected, presumably due to different types of nitrogen excretion. More information on factors influencing trophic discrimination factors is needed to obtain reliable estimates of trophic position in the field. This study represents the first attempt to adapt dual analysis of ^{13}C and ^{15}N in amino acids for analyzing the structure of soil animal food webs and suggests that this method allows shedding light into the cryptic world of soil animals, providing more precise estimates of basal resources and trophic positions of species than bulk isotope analyses.

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Shifts in trophic strategies of reef-building corals following seawater temperature anomaly**Veronica Z. Radice**¹, Brian Fry², Ove Hoegh-Guldberg^{1,3}, Michael D. Fox⁴, Sophie G. Dove¹

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Regional oceanographic processes like upwelling serve an important role in shaping tropical marine ecosystems by distributing nutrients to otherwise oligotrophic seas. In coral reef ecosystems, nutrient availability can differ depending on reef exposure and depth. Although reef-building corals generally rely on endosymbiotic dinoflagellates (herein symbionts) for food, corals can supplement their nutrition by feeding on particulates. Recently, trophic strategies of corals are being disrupted due to increasing seawater temperatures causing coral bleaching, or the breakdown of symbiosis between coral hosts and symbionts resulting in pigment loss. Using carbon and nitrogen stable isotope ratios ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$), we investigated the influence of upwelling on the trophic ecology of corals. Three species of coral hosts, their symbionts, and particulate sources were sampled from shallow and deep reefs (10-30 m) one year before and after coral bleaching in the Maldives, Indian Ocean. Overall, consistent $\delta^{15}\text{N}$ values of hosts and symbionts (~ 4 to 6‰) from different reef exposures and depths suggest deep-water nitrate from upwelling is the major nitrogen source sustaining corals across this large reef system. In contrast, the greater range of $\delta^{13}\text{C}$ values ($\sim 10\text{‰}$) revealed species-specific strategies with each species occupying distinct isotopic niches and only one species showing differences between depths. One year after coral bleaching, coral host $\delta^{15}\text{N}$ values of all species were significantly higher by 0.5‰ and approached plankton $\delta^{15}\text{N}$ values. In contrast, symbiont $\delta^{15}\text{N}$ remained similar except for a decline in one species from deep reefs. Considering the slow turnover of nitrogen in corals, increased host $\delta^{15}\text{N}$ may reflect greater feeding on particulates when the symbiosis was disrupted. We hypothesize that increased feeding is related to larger differences between host and symbiont $\delta^{15}\text{N}$ values, which we found was correlated with a greater percent of long-chain monounsaturated fatty acids that are characteristic of copepods. Host and symbiont $\delta^{13}\text{C}$ were largely similar before and after bleaching, with lower $\delta^{13}\text{C}$ observed for species considered more capable of feeding. Although coral colony abundance across depth was different among species, similar distributions before and after bleaching suggests that these species were able to persist during a bleaching event that severely affected the reef.

Uncovering soil food webs using bulk natural stable isotope composition

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Despite the major importance of soil biota in nutrient and energy fluxes, trophic structure of soil food webs is poorly understood. Here we provide an overview of recent advances gained by applying stable isotope analysis to study the trophic structure of belowground communities. We compiled data on natural variations of stable isotopes of C and N in soil invertebrates across temperate forests originating from 23 published studies (Europe, Japan, USA). Analysis of the dataset and existing literature revealed the following general patterns: (1) In contrast to aboveground and aquatic food webs, trophic fractionation at the basal level of detrital food webs is large for carbon and small for nitrogen stable isotopes, which underlines the importance of microorganisms as the major food resource for the soil animal community. (2) Difference in ¹⁵N and ¹³C enrichment between soil and leaf litter results in heterogeneous isotopic baseline within a community and this complicates delineation of trophic levels of species. At the same time, decomposers in litter and soil differ little in ¹³C content, suggesting that they rely on similar C sources. (3) Direct feeding on living roots is likely of minor importance for the whole community, whereas feeding on photoautotrophic microorganisms may have been underestimated. (4) Consumption of living mycorrhizal mycelia by soil fauna is very limited contrasting the large biomass and ubiquitous distribution of mycorrhizal fungi, potentially contributing to carbon sequestration in soil. (5) Despite overlap in feeding strategies, averaged stable isotope composition of the high-rank taxonomic groups reflects differences in trophic level and in the use of basal resources. Different taxonomic groups of predators and decomposers are likely to be linked to different pools of organic matter in soil, indicating that trophic niches in soil animal communities are phylogenetically structured. Extending the use of stable isotope analysis to a wider range of soil-dwelling organisms, including microfauna, and a larger array of ecosystems provides the perspective of a comprehensive understanding of the structure and functioning of soil food webs.

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PD387PF

Soil isotope ecology

Oral presentation Monday 30 July 2018

How do wetlands and grasslands influence the ecohydrological functioning of the Andean Paramo?

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The Paramo is a high-elevation tropical ecosystem known as the "water tower" of northern South America. This tropical montane ecosystem situated above the tree line provides a variety of ecosystem services that help sustain the ecological diversity and the socio-economic development of the Andean region. Despite its socio-ecological importance, the factors controlling the Paramo provisioning of high-quality water remain poorly understood. To fill this knowledge gap, this study provides the first evaluation of how the Paramo ecological units (grasslands and wetlands), which have resulted from the unique combination of the Paramo soils (Andosols and Histosols) and their corresponding overlaying vegetation cover (tussock grass and cushion plants, respectively) and which heavily depend on local environmental conditions (cold and humid), influence the ecohydrological functioning of the ecosystem. The study site is the Zhuruca Ecohydrological Observatory located in south Ecuador between 3,400 and 3,900 m a.s.l. The observatory was equipped for the weekly collection of water samples in precipitation, streamflow, and soils below the Andean Paramo grasslands and wetlands over a 3-year period. The water samples were used to determine the ^{18}O and ^2H isotopic composition among the different parts of the landscape. These data were used to investigate how grassland (mainly located in hillslopes) and wetlands (mainly located at flat areas) soils contribute to ecohydrological flows. The isotopic concentrations indicated that even when only 15-20% of the Paramo landscape is covered by wetlands, water stored in the Histosol soils underlying these ecological units contribute to 80-90% of the ecohydrological flows year-round. The Andosols soils, which underlain the grassland type vegetation and cover 85-90% of the landscape, in turn, help regulate the generation of ecohydrological flows by recharging the wetlands at the valley bottoms during dry periods. These findings highlight (i) the importance and the fragility of riparian wetlands as the main water storage reservoir and (ii) the connectivity between grasslands and wetlands to help regulate ecohydrologic flows in the Andean Paramo. Our findings indicate that the management of Paramo landscapes should be conducted from a holistic perspective, since changes in land use and climate can severely affect the ecosystem soil-vegetation-atmosphere continuum.

PLENARY TUESDAY 31 JULY 2018 09:00 - 10:00.

Evolutionary and phenotypic responses to the use of marine resources in terrestrial songbirds: lessons from isotopic ecology.

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Songbirds (Passeriformes) have diversified in all continents and occupy nearly all terrestrial ecosystems, but only a few species in this group inhabit marine and coastal environments. Life in saline environments represents a major physiological challenge for birds, particularly for passerines that lack nasal salt glands and hence are forced to live in environments that do not contain salty resources. We explore the presumed links between physiological traits and marine resource use in five species of the genus *Cinclodes*, the only passerine genus that exhibits intra- and interspecific differences in marine resource use. We used a combination of carbon, nitrogen, and hydrogen isotope data from metabolically active (e.g., blood and liver) and inert (feathers) tissues to estimate intra and interspecific differences as well as seasonal changes in marine resource use and infer altitudinal migration. In our first example, we described inter-specific differences in the degree of isotopic and dietary specialization in three species that occupy coastal and/or freshwater environments: *Cinclodes patagonicus*, *Cinclodes oustaleti* and *Cinclodes nigrofumosus*. In the second example we show that changes in reliance from terrestrial to marine food diets were accompanied by evolutionary changes in renal structure and function. In a third example we used the $\delta^{13}\text{C}$ of *C. oustaleti* and *C. nigrofumosus* tissues to investigate whether the reliance on marine versus terrestrial sources varied from the hyper-arid north to the wet south and revealed how latitudinal variation in the renal traits mediate how these birds cope with dehydration and a salty marine diet. Finally, we showed that some of the ecological traits unique to *Cinclodes*, such as persistent or seasonal marine resource use coupled with altitudinal migration, are correlated with organismal (e.g., metabolic rates) and biochemical (e.g., oxidative status) physiological traits. Taken together, these particular examples of the auto-ecology and ecophysiology of this particular group of birds allow us to emphasize that southern South America is an ideal region to study altitudinal and latitudinal movement in animals by means of stable isotope analysis and that stable isotopes appear to be a powerful tool for comparative studies, albeit one that remains under-utilized.

BD181CN

Isoscapes and movement ecology

Oral presentation Tuesday 31 July 2018

Applications of sulphur isotopes in freshwater food webs

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Stable isotopes of sulphur ($^{34}\text{S}/^{32}\text{S}$) have long proven useful for ecological applications in coastal settings. Distinct gradients between freshwater and marine environments, and strong differences among organic matter sources, allow tracing of diets and movements of mobile organisms as they move across the freshwater/saltwater interface. Yet sulphur isotopes are rarely used in inland systems. We seek to change that by showing two examples of how $\delta^{34}\text{S}$ can reveal trophic connections among freshwater ecosystem types (rivers, lakes, wetlands) as mediated by moving organisms. First, we show how large-bodied fishes in a northern Canadian river basin, the Slave River, undertake seasonal movements from Great Slave Lake into the river to spawn. Two distinct groups of fishes appear at riverine sites, one isotopically aligned with lake food sources ($\delta^{34}\text{S} = 2$ to 6 permil) and the other aligned with river sources ($\delta^{34}\text{S} < 0$ permil). The differentiation of these two groups allows better estimation of exposure to contaminants carried by the river. Second, we reveal how a small insect, the water boatman (Family Corixidae), connects hydrologically-isolated wetlands to rivers and lakes by seasonal flight. Swarms of water boatmen found in rivers in the fall had $\delta^{34}\text{S}$ values (-20 to -10 permil) that matched wetland sources and differed from local prey in the river ($\delta^{34}\text{S} = -10$ to 0 permil). Some fish species, including goldeye, white sucker and longnose sucker, feed heavily on these insects and $\delta^{34}\text{S}$ is being used to estimate proportional contributions to their diets on different time scales using different tissues. We believe that inclusion of $\delta^{34}\text{S}$ into routine isotopic analyses of freshwater food webs can yield enormous benefits for source tracing and establishing origins of freshwater biota.

BD564GS

Isoscapes and movement ecology

Oral presentation Tuesday 31 July 2018

Land-ocean connectivity in a Brazilian subtropical bay: using $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isoscapes to link terrestrial inputs, algae and benthic consumers

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Land-ocean connectivity in the form of terrestrial inputs can constitute an important subsidy to recipient coastal and marine systems. Here, I describe recent insights from studies done within a seasonally-pulsed bay in subtropical Brazil. Spatiotemporal variation in the isotopic signals ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) of plants and benthic invertebrates were used to generate isoscapes that helped to investigate: (a) the sensitivity of benthic indicators to seasonal shifts in the dominance of sewage vs. terrestrial inputs driven by fluvial forcing (i.e., environmental pollution assessments); and (b) seasonal variation in the importance and spatial footprint of marine vs. terrestrial food sources to common benthic consumers (i.e., diet analysis using isotope mixing models). Results confirmed that during the dry season (winter), sewage was the dominant source of nitrogen to producers and benthic consumers through trophic relay. Further, consumers relied predominantly on marine sources of food (seagrass and algae). During the wet season (summer) however, riverine inputs reduced the dominance of sewage nitrogen within the bay and increased the contributions of terrestrial subsidies (grassland vegetation) as a food to marine consumers. Overall, these studies highlight the applicability of isoscapes as a means of mapping seasonal and spatial variation in the footprint of terrestrial inputs to coastal and marine environments.

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Isoscapes and movement ecology

Oral presentation Tuesday 31 July 2018

The geographic extent of solar energy effects on California avian populations

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One of the recognized environmental impacts of renewable energy generation is the widespread fatality of avian wildlife that accompanies the operation of such facilities. A central challenge to mitigating this impact requires an understanding of the demographic mechanisms and geographic scope of these effects on avian populations. Our research is focused on use of hydrogen stable isotope analysis to characterize the geographic origin of the bird carcasses found at solar energy facilities in California. Values of hydrogen stable isotopes (d^2H) in precipitation vary across continental gradients, and this signal is incorporated through the food web into animal tissues at the time of growth. Therefore, feather d^2H values reflect the location feathers were grown and can be used to assess the likely region of geographic origin. Using input from policy-makers and stakeholders, we identified a group of 32 priority species for study. We obtained feather samples from 561 individuals of 24 of the priority species killed at six solar facilities, and we modeled the likely origin of these individuals to characterize the local or migratory status. Preliminary results indicate that the geographic footprint of impact extends far beyond the local region, and we highlight the patterns for several species for which this is the case. For example, migrants composed 78% of the American kestrel samples, 73% of the western meadowlark samples, and 100% of the eared grebe samples. These efforts will help to identify the demographic consequences for avian species that are affected by solar energy operations.

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Isoscapes and movement ecology

Oral presentation Tuesday 31 July 2018

Models, migration and connectivity

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When we try to draw ecological inferences from stable isotope data, we are often limited by a lack of knowledge of the isotopic context for our samples. This is especially true in open marine systems where spatially explicit sampling of isotopic baselines is logistically challenging, and temporal variation may be relatively large. In such data-limited systems, mechanistic isotope models can provide valuable isotopic context, providing the limitations of model products are clearly understood. Here we outline three contrasting ways of using global simulated isotope baselines to provide isotopic context. At the level of individual animals, we couple individual-based movement models to dynamic isotope models to simulate isotopic profiles across incrementally-grown tissues. Simulated and measured data can then be compared to infer likely movements under different isotopic assumptions. This approach is most suitable for reconstructing individual movements where isotopic data are sampled at relatively high frequency across incrementally-grown tissues. We demonstrate the application by reconstructing 7 years of movement behaviour of a blue whale in the North Atlantic based on a measured baleen isotope record. Isotopic data from historic tissue archives are increasingly used to infer climate change or ecological responses to change, but variations in isotopic compositions over time may reflect changes in trophic behaviour, location and climate or population demographics. We use Atlantic salmon as a case study to show how simulation models can be used to explore the potential significance of multi-decadal records of isotopic variability within- and between-populations. Finally, global compilations of isotopic data offer potential to draw broad scale ecological insights, but only where isotopic context can be carefully described. We draw on recent experience attempting to infer movement ecology from a global compilation of shark isotope data, and show how simulation models were critical to revealing and understanding pattern in the data.

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Isoscapes and movement ecology

Oral presentation Tuesday 31 July 2018

Source-consumer isoscapes reveal an uncoupling of energy and protein inputs in human diet with local carbon and nitrogen sources in Brazil

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Brazilian populations are experiencing dietary changes characteristic of nutrition transition, with an increase of diet homogenization as locally-produced food is replaced with processed and ultra-processed food. Despite this trend toward a “global supermarket” diet, we investigated whether carbon and nitrogen isotopic compositions of Brazilian inhabitants can still hold dietary information related to both regional food sources and dietary practices. We measured carbon and nitrogen stable isotope ratios of fingernails from about 4000 Brazilian inhabitants living both in rural and urban areas in different geographic regions. Carbon and nitrogen isotope ratios of fingernails were spatially distributed across Brazil, as were the carbon and nitrogen isotope ratios of soil. The degree of variation appears to vary between urban and rural settings, but also among geographic regions; regional change was associated with regional agricultural and animal production practices. Independent of region, we found a gradual increase in the number of food items derived from C4 plant resources (meat and sugar) and the replacement of food items derived from C3 plant resources (rice and beans) with increasing size of urban centers. Using cluster analysis and the interpolation of soil and fingernail isotopic compositions, we observed significant differences on how coupled or decoupled human dietary patterns may be from local carbon and nitrogen sources. Fingernails from individuals living in agricultural regions had a strong link to local carbon and nitrogen isotope signatures while fingernails from individuals living more urban settings, where diets were changing, had the most decoupled isotopes signatures from local landscapes. The association of source-consumer isoscapes proved useful as a proxy for tracking geographic diet patterns of Brazilians facing important dietary changes; the isoscapes also proved useful for investigating the degree of intensity of such diet changes. This integrated approach using source-consumer isoscapes can be used both in human nutrition studies but also in tracking human movements in forensic anthropology studies.

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Isoscapes and movement ecology

Oral presentation Tuesday 31 July 2018

Can we track livestock mobility using high-resolution of C & N isotopic analysis of keratin? A case study using GPS tracking in Mongolian Altai

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For pastoralists, movements between pastures are necessary in order to secure food access to livestock. In mountainous areas, this is usually done along an altitudinal gradient. The origin of vertical mobility is not well known, and different studies have attempted to infer past altitudinal mobility through isotope analyses of archaeological teeth. Although the method can detect large-scale migrations, its potential for characterizing small-scale movements of livestock remains unclear. To assess the reliability of this approach, we combined GPS tracking and high-resolution isotopic analysis of horse and caprines of five herders from Mongolian Altai. GPS collars were scheduled to record animal location every 13h during one to two years between June 2015 and November 2017. Tail hair and horn were collected and longitudinally sampled every 0.75 cm and 2 mm respectively to provide high-resolution isotopic records of their diets. During the survey period, the horses and caprines moved on average 7.5 (+/- 2.5) and 8.9 (+/- 2.7) times between pastures located between 1500 and 3000m respectively. On average horses and caprines stayed 45 (+/- 40) days and 40 (+/- 38) days on each pasture, respectively. We observed a great variability in mobility frequency within our dataset. Moreover, this mobility frequency was higher, for some individuals, than what models commonly describe for Western Mongolia. Variations in carbon (4.4 per mil for horses and 2.7 per mil for caprines in average) and nitrogen (6.3 per mil and 3.6 per mil in average) isotopic values were detected along tissues. However, while some isotopic excursions could be linked to animal movements, others were more difficult to assign. This could either be due to the lack of isotopic heterogeneity between pastures or to residence times too short to allow the pasture signature to be recorded in hair keratin. These preliminary results highlight the difficulty to discriminate isotopically longitudinal and vertical mobility in the context of C3-dominated mountain steppe ecosystems.

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Isoscapes and movement ecology

Oral presentation Tuesday 31 July 2018

Latitudinal isotopic variability in Southern Ocean suspended particulate organic matter validates Southern Ocean isoscapes and informs humpback whale trophic ecology

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Underway suspended particulate organic material (SPOM) was sampled during two voyages (2010 and 2015) on latitudinal transects from New Zealand to Ross Sea shelf and along the shelf edge, generating $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ baseline isotopic values in the areas traversed. Measurements of underway temperature, salinity, chlorophyll a, HPLC, and fluorometry enabled key water masses and oceanographic features to be identified and variations in SPOM isotopic values to be interpreted. Whilst a strong gradient in $\delta^{13}\text{C}$ was observed throughout most of the transect (reflecting predicted decreases in $\delta^{13}\text{C}$ with increasing latitude), non-linear temperature- $\delta^{13}\text{C}$ relationships were observed in the sub-Antarctic front, sea-ice melt areas and highly productive areas, such as around the Balleny Islands. These data have been used to ground truth a modelled Southern Ocean carbon and nitrogen isoscape, and have subsequently been used to interpret the trophic status and diet of humpback whales studied around, and to the east of, the Balleny Islands.

MC576SB

Isoscapes and movement ecology

Oral presentation Tuesday 31 July 2018

New methods of isoscape development: the good, the bad and the variability

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The creation of isoscapes in terrestrial, and more recently marine, environments has expanded notably over the past decade. Methods for producing continuous surface spatial models of isotopic variability are numerous, but many isoscape models combine spatial interpolation with information from statistical relationships between isotopic data and environmental variables. Isoscapes are commonly used to geolocate migratory animals to their foraging areas or origin and the accuracy and precision associated with isoscape-based geolocation depends on the uncertainty accompanying the isoscape model. Unfortunately, estimating spatially-varying uncertainty is challenging for most commonly used isoscape models, especially where reference datasets are compilations of data combining multiple sources, methods or reference organisms. Here we present a novel Bayesian hierarchical statistical modelling approach using R-INLA. We predict spatial variation in the isotopic composition of carbon, nitrogen and sulfur in predatory zooplankton (jellyfish) across a large marine shelf sea area (the combined UK shelf seas). This approach enables us to consider systematic variations in reference isotope samples (in our case different jellyfish species) by incorporating a spatial random effect component into the model. Compared to alternative isoscape prediction methods, INLA-spatial isotope models show high spatial precision and reduced variance. We illustrate the implications of using improved isoscape models for geo-assignment by comparing the accuracy and precision achieved when assigning sessile and mobile marine organisms to known locations using INLA and more familiar kriging-based isoscape models. We also demonstrate how increased spatial precision (lower residual error in spatial prediction) in isoscape models, often considered ideal in isoscape development, limits the applicability of an isoscape across time. Techniques are presented in a marine setting drawing on carbon, nitrogen and sulfur isotope systems, but the same methods and limitations are applicable to isoscape development and use across all environments and isotope systems.

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Isoscapes and movement ecology

Oral presentation Tuesday 31 July 2018

Intraspecific variation in exploratory behavior and elevational affinity in *Zonotrichia capensis*

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Populations of the same species can vary substantially in their behavioral and morphometric traits when they are subject to different environmental pressures, which may lead to the development of different adaptive strategies. We quantified variation in exploratory behavior and morphometric traits among two rufous-collared sparrow (*Zonotrichia capensis*) populations that occur at low and high elevations in central Chile. Moreover, we used census and $\delta^2\text{H}$ values of feather and blood to evaluate migration. We found that individual sparrows inhabiting high elevations were larger and showed more intense exploratory behavior in comparison with those that were captured at lower elevation. Moreover, we observed a steady decline in sparrow abundance during the winter and similar $\delta^2\text{H}$ values for blood collected in the winter and summer at this site, which were significantly lower than blood $\delta^2\text{H}$ values observed at low elevation. This pattern suggests that individuals do not move long distances during winter, and likely they remain at similar elevations in refuge habitats. As predicted, our results support the existent of different adaptive strategies among populations of the same species, and suggest that the combination of behavioral, morphometric, and stable isotope data is a novel and robust integrative approach to assess differences in adaptation across environmental gradients.

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Biogeochemical cycles and global change
Oral presentation Tuesday 31 July 2018

Carbon, chironomids, and climate change

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Chemosynthetic production, primarily derived from methane, has been identified as a widespread and often significant contributory resource to aquatic food webs around the globe. Stable isotope analysis has been a key tracer because methane typically has a markedly distinct $\delta^{13}\text{C}$ (^{13}C -depleted) signal, and there is potential to use δD to good effect too. As recognition of the possibility of methane-derived carbon (MDC) providing an alternative energy source to food webs has grown, so the emphasis on research has shifted from point sources (such as methane vents and seeps) to ever more diffuse sources (in free-flowing rivers), and less intuitively obvious locations where it might be relevant. Reliance has been estimated as high as 80-100% for vent communities compared to 0-20% for primary consumers in groundwater-fed rivers. The proportion of MDC contributing to food webs at diffuse sources may well be smaller (but still of significance); as such, there is likely to be greater ambiguity in the stable isotope signal picked up in the food web, and so the importance of MDC might have been overlooked in many of these systems. Complementary tools or experimental manipulation will be necessary to study this further. A considerable amount of research has focussed on lake ecosystems, and particularly those that stratify, highlighting the trophic transfer of MDC via benthic chironomids to both aquatic and terrestrial higher consumers. Paleolimnological samples have been used to good effect in 'hindcasting', to demonstrate how contributions from MDC to lake food webs have waxed and waned over centuries, often in response to anthropogenic change (especially nutrient enrichment) within the catchment. But what of the future? Analyses of long-term data series from lakes demonstrate that many are subject to increasing average water temperature which can directly exert a strong control on methane dynamics via the physiological stimulation of microbial metabolism. Does more methane equate to more MDC in the food web? Here, I explore how the use of MDC is likely to alter under climate change scenarios and how the continued use of the stable isotope toolbox will be essential to further our understanding.

Natural Environment Research Council; Max Planck Society; British Ecological Society

“ISOTOMICS” or reading the big books (tomes) of position-specific isotope analysis (PSIA) information; initial amino acid PSIA studies of fish and prawns from a marine food web, Moreton Bay, Australia

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Stable isotopes are widely recognized dietary tracers in food web studies, but their application to study metabolic consequences of diets is still poorly developed. We have developed a new position-specific isotope analysis (PSIA) methodology to characterize animal diets and metabolic responses, analysing $\delta^{13}\text{C}$ of amino acid carboxyl groups ($\delta^{13}\text{C}_{\text{CARBOXYL}}$). The new methodology uses the ninhydrin reaction to cleave carboxyl groups from essential (indispensable or dietary) amino acids and non-essential (dispensable or metabolic) amino acids. The resulting CO_2 is analysed for $\delta^{13}\text{C}_{\text{CARBOXYL}}$ to indicate diet and metabolic responses to diet. Initial results show at least three types of diets are present in fish and prawns from the Moreton Bay estuary that adjoins the city of Brisbane, Australia. Two indispensable dietary amino acids, isoleucine and leucine, record a major division in planktonic vs. benthic food webs, and two dispensable metabolic amino acids, serine and glycine, seem to record a differential metabolic response to these diets. We analysed 17 common amino acids per animal from about 30 fish and prawns, calculating paired isotope differences (e.g. the difference in $\delta^{13}\text{C}_{\text{CARBOXYL}}$ values of the amino acid pair, glycine and serine) for all the 136 possible $\delta^{13}\text{C}_{\text{CARBOXYL}}$ pairs. Each animal could be uniquely represented by the resulting isotope difference spectrum. The information-rich PSIA and isotope spectrum approaches open the information treasure chest present at the fundamental level of isotope information in organic compounds, the atom-specific or position specific level, here measured as the carboxyl groups of the amino acids. This new PSIA frontier is different than the bulk (whole tissue) or compound (whole molecule, CSIA) levels that average the position-specific information; PSIA allows an expanded and clear view of the fundamental or true isotope variation in environmental samples. The PSIA information has been estimated to exceed that available from genetics, and working at the PSIA frontier may yield rewards in many fields in the future, such as understanding diets and their metabolic consequences for humans as well as wildlife. A new word representing this frontier of reading the big books (tomes) of isotope PSIA information is “ISOTOMICS”; older words for this same endeavour are “isotopics” and “isotopomics”.

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Biogeochemical cycles and global change
Oral presentation Tuesday 31 July 2018

Does biochar amendment reduce N₂O emissions by stimulating the last step of denitrification? - A study using position-specific N isotopic composition

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Biochar amendments often decrease N₂O gas production from soil, but the mechanisms and magnitudes are still not well characterized since N₂O can be produced via several different microbial pathways. To identify the specific pathways responsible for N₂O production, ¹⁵N site preference (SP) derived from isotopomer analyses of N₂O is often used. SP is the difference between the d₁₅N of the central (a) and terminal (b) N of the linear N₂O molecule, which vary as a function of N₂O source. We incubated an agricultural soil with different amounts of biochar to evaluate the influence of biochar amendment on N₂O emissions and SP. Incubations were run for 10 days under anoxic conditions, with and without acetylene which inhibits N₂O reduction to N₂. SP analyses were performed after 5 days of incubation. The SP values with acetylene were close to 0 permil, consistent with N₂O production by bacterial denitrification. The SP values without acetylene were 10-17 permil, consistent with bacterial denitrification that included N₂O reduction to N₂. There was no effect of biochar on N₂O production in the presence of acetylene, suggesting biochar did not affect N₂O production after 5 days of incubation. However, in the absence of acetylene, soils incubated with 4% biochar produced less N₂O than soils with no biochar addition. These results strongly suggest that biochar enhances the last step of denitrification (N₂O reduction to N₂). Low concentrations of NO₃⁻ and NO₂⁻ in all soils after 10 day incubation also support this. Partial N₂O reduction should increase the SP values of residual N₂O as the ¹⁴N-O bond is easier to break than ¹⁵N-O. The SP values of Day 5 samples with 4% biochar, however, did not significantly differ from those of samples with no biochar addition. This indicates that biochar amendment might have altered the microbial taxa to species that reduce N₂O with different SP, or higher percentage of biochar amendment is required for SP to show a significant difference from soils without biochar addition. Our N₂O emission, SP, and inorganic nitrogen concentration results demonstrated that biochar amendment reduces N₂O emissions by stimulating the last step of denitrification.

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Biogeochemical cycles and global change

Oral presentation Tuesday 31 July 2018

Stable water isotope as climate tracers in the Laclavere Plateau, Antarctic Peninsula

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In the last decades the Antarctic Peninsula has presented the highest temperature increase of the southern hemisphere for the recent decades. The lack of instrumental meteorological records has hindered the study of regional climatic trends. In this context the study of ice cores has become a powerful source of information because they contain records of greater temporal extension and from areas where meteorological information hasn't been retrieved. Laclavere Plateau (LCL) (63°27'15"S / 57°41'53"W / 1130 m.a.s.l.) is situated in the northern tip of the Antarctic Peninsula. The climatological regime in the north of the Peninsula presents a complex interaction between the different elements that form the climatic system. Meteorological conditions in this area are controlled by the variation in the sea ice extension, the position of the Antarctic Circumpolar Current and the differences in the lapse rate throughout the year. Since 2008, we have studied this region, where several surface firn cores (<20m) have been collected from sea level to the divide between west and east coast at LCL. The isotope signature of the cores shows a complicated signal to interpret: In general, no clear seasonality is observed. Here we show the statistical treatment that allow us to conclude that the deuterium excess, oxygen and deuterium ratios can potentially be used as a seasonal marker. We propose that variations observed in the signal and in meteorological conditions are related with the development of an inversion layer in the lower troposphere (below 1000 m.a.s.l.) during the formation of sea ice. We estimate that LCL present appropriate conditions for the conservation of the isotopic signal accumulated on its surface. Therefore, we conclude that isotopic signal recovered from LCL is a strong indicator of meteorological parameters, which make them capable of being a proxy of local variability in atmospheric circulation, snow accumulation and air temperatures. The isotope signal, along with the thick ice cover over the LCL (surveyed by geophysical methods), project this place as a favorable spot to recover a medium depth ice core (>250m), from which it could be developed a paleoclimatic reconstruction covering at least the last century.

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Biogeochemical cycles and global change

Oral presentation Tuesday 31 July 2018

Non-rainfall water origins and formation mechanisms in the Namib Desert

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In dryland ecosystems, non-rainfall water (e.g., fog and dew) is an important component of the hydrological cycle that can exceed annual rainfall. Despite its acknowledged importance, non-rainfall water is often the least studied component of the hydrological cycle as research often focuses on limiting factors rather than factors sustaining productivity. It is often assumed that non-rainfall water in coastal drylands is advected from the ocean, but many dryland regions have groundwater resources that could contribute to non-rainfall water in these areas. However, we are not aware of any systematic studies that have investigated this possibility. In addition, most field and modelling studies tend to silo non-rainfall input due to technical constraints, which hinders prediction of dryland responses to future warming conditions. In this study, we used multiple stable isotopes (^2H , ^{18}O and ^{17}O) to investigate the non-rainfall water origins within the Namib Desert fog zone. Isotope based results showed that fog and dew have multiple origins and that groundwater in drylands can be recycled via evapotranspiration and redistributed to the upper soil profile as non-rainfall water. Our results showed that at least three types of fog (advective, radiation and mixed) occurred in this region and what appears as a single fog event may include all three types depending on location. Surprisingly the non-ocean derived (radiation or mixed) fog accounted for more than half of the total fog events, suggesting a potential shift from advective dominated fog to radiation dominated fog. Such shift has implications in changes in the flora and fauna composition in this fog dependent system. We also firstly demonstrated that fog and dew can be differentiated based on the dominant fractionation (equilibrium and kinetic) processes during their formation using the ^{18}O - ^{17}O relationship. Our results are of great significance in an era of global climate change where the importance of non-rainfall water increases as rainfall is predicted to decline in many dryland ecosystems.

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Isotopic analysis of soil organic carbon: critical insights into belowground tree-grass interactions in savanna ecosystems

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Savannas are extensive and provide important ecosystem services. They are characterized by coexistence of trees and grasses. The mechanisms that control coexistence of trees and grasses in savannas are not fully understood, and *in situ* observations of belowground components (soils and roots) are particularly sparse. Here, we used stable isotopes of carbon ($\delta^{13}\text{C}$) in soils and plants to examine tree-grass interactions, carbon cycling, and nitrogen inputs in a savanna ecosystem along a steep precipitation gradient (180 – 540 mm precipitation yr⁻¹). Soil samples were collected in four study sites, in the top 1.2 m of soil at depths 10, 30, 70 and 120 cm. Soil $\delta^{13}\text{C}$ values at 30 cm were higher than at other depths in all the sites, possibly indicating the importance of grass-derived C at this depth. Conversely, the mean tree-derived SOC was highest at 10 cm and 70 cm in all the sites. Along the precipitation gradient, tree- and shrub-derived soil organic carbon (SOC) was found to be highest in the wettest and driest sites, 63.8% and 55.8%, respectively. The grass-derived SOC was found to be highest (69.4%, 1721.0 g m⁻²) in the middle of the precipitation gradient. The relatively high $\delta^{13}\text{C}$ values at 30 cm and lower $\delta^{13}\text{C}$ values at 10 cm and below 30 cm in the soil profile, and the associated soil C input from trees and grasses suggest a more complex interaction between trees and grasses than previously thought. Our results indicate a shallow top and thick bottom layer dominated by lateral and vertical tree roots respectively, while the middle layer is dominated by grass roots. Therefore, our results suggest that savanna ecosystems in the Kalahari could have a three-layer root system contrary to the commonly perceived Walter's two-layer root hypothesis. In light of these findings, we propose a three-layer root hypothesis, which could explain the tree-grass coexistence in dry and mesic savannas.

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Biogeochemical cycles and global change
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Applications of carbon stable isotopes in marine carbonate system and ocean acidification studies

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Stable isotopes can integrate ecological and biogeochemical processes in space and time. Moreover, carbon isotopes can trace the origin and movement of key elements and substances, owing to isotopic fractionations associated with physical/biological reactions. Carbonate chemistry is highly variable in both space and time in the coastal domain along many land-ocean interface regions worldwide. River runoff, coastal upwelling, organic matter remineralization/respiration, all constitute significant sources that could be affecting the Dissolved Inorganic Carbon (DIC) pool in the ocean. For instance, the dissolution of carbonates rocks along the river basin, atmospheric CO₂ dissolution, and biogenic CO₂ resulting from bacterial respiration of marine terrestrial organic matter may all contribute to DIC pool in river-influenced coastal water. Isotopic tools could be, therefore, useful to identify the contribution of different DIC sources driving changes in the carbonate system along the river and in the adjacent coastal domain. We have observed through different field campaigns that in river plume waters, the respiration of terrestrial organic matter and weathering of carbonate minerals may influence $\delta^{13}\text{C}_{\text{DIC}}$, which results in an isotopically depleted pool compared to oceanic DIC. In contrast, the pulses of low pH and high $p\text{CO}_2$ acidic waters during coastal upwelling provide an additional DIC pool for biological productivity and or biogenic carbonate. Indeed, $\delta^{13}\text{C}_{\text{DIC}}$ is often used as a tracer of upwelling strength. In the coastal ocean, marine calcifiers (e.g. corals, mollusks, echinoderms) incorporate DIC from these different sources for shell construction, but they can also use CO₂ from their own metabolic/respiratory process. By conducting analysis of stable isotope of carbon in shell CaCO₃, we can also determine the relative contribution of these different carbon sources for shell construction. All these applications are very useful when we also trying to understand carbon pathway and fractionation upon $p\text{CO}_2$ -driven ocean acidification conditions. Here, many of the ways in which stable isotopes are used in carbon chemistry and ocean acidification studies are reviewed, based on different study cases along the Chilean marine realm. Finally, a brief subjective view of possible future advances is also made.

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Biogeochemical cycles and global change

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$\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotope proportion in effluents of land based fishfarms in north-Patagonian streams.

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Chile has the second largest production of salmon worldwide (ca. 800.000 & ca. 30% of global total). As part of the salmon farming process, early life stages are grown in land-based aquaculture facilities before they are transferred to marine sites. Although important in terms of provision of employment and wages in an area with low employment rates, these aquaculture facilities are typically located on pristine low order streams which they pollute through the discharge of large amounts of organic waste. This input of highly labile and mainly dissolved organic matter has a high potential to disturb stream metabolism, deteriorating water quality and generating stress in fluvial ecosystems. However, although impacts are likely significant, there has been little study of the fate and impacts of dissolved organic matter pollution from this key aspect of aquaculture in northern Patagonia. Here, we present the first results of analysis of dissolved organic matter (SPE-DOM) $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$, obtained from aquatic matrices coming from effluents of 5 fish farms located in northern Patagonia. The results clearly show distinct isotopic values in aquaculture effluents ($\delta^{13}\text{C}$ -27.91 ± 0.81 ; $\delta^{15}\text{N}$ 3.56 ± 2.32) compared to values from non-impacted streams effluents ($\delta^{13}\text{C}$ -29.17 ± 0.66 ; $\delta^{15}\text{N}$ -1.72 ± 0.95). These isotopic differences make it possible to estimate the effective DOM load from the fish farms (where we estimate an emission of 200 kg C and 40 kg N per ton of produced fish), highlighting the utility of the method as a tool as a means of assessing environmental impacts of human activities in aquatic environments.

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Biogeochemical cycles and global change

Oral presentation Tuesday 31 July 2018

Geochemical evidence of predominantly autochthonous organic carbon contributions to the sedimentary organic matter pool of Laguna Garzon in Uruguay

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The composition and mineralogical properties of sedimentary organic matter (SOM) within an intermittently open coastal lagoon in Uruguay were analysed using optical properties of dissolved organic matter (DOM), stable isotope analyses ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) and Fourier transform infrared spectroscopy (FTIR). Additionally, chemical and biological parameters including total nitrogen (TN) and total phosphorus (TP), and chlorophyll *a* were analyzed. Potential SOM sources end-members (e.g. marine, riverine phytoplankton, and terrestrial plant material) and fauna were collected during summer, autumn, winter along the increasing salinity gradient from south to north. In the pore water, the high contribution of fluorescent protein-like peaks, the $\delta^{13}\text{C}$ values of sediments that ranged from -22 to -16‰ and, together with the low C/N ratios of sediments within the lagoon (~ 7), confirm the dominant source of SOM as marine microalgae. Most of the diatom species found in the sediments were benthic marine/brackish species including the polyhaline *Pseudopodosira echinus*. Isotopic analyses of the SOM indicate that the contribution from surrounding terrestrial vegetation is relatively minor in the benthic system. Furthermore, FTIR spectra showed higher relative absorption intensity at the bands of quartz, carbonates and feldspar contents towards the south region of the lagoon with weak absorption in band region of biogenic silica as a general pattern. Clay minerals seem to be associated with higher absorption intensity in sediments from the north region, indicating changes in the hydrodynamic energy within the lagoon with greater overall rates of sediment deposition in the north. An active resuspension and mixing condition due to the shallow depth might determine a strong coupling between the benthic production and water column.

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Biogeochemical cycles and global change

Oral presentation Tuesday 31 July 2018

Reconstructing decades of food web structure in the North Pacific and Bering Sea using bulk and compound-specific stable isotope analyses from archived northern fur seal teeth

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Physical and biological conditions in the North Pacific (NP) and Bering Sea (BS) vary on different multi-year scales due to natural climate variations from El Niño Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO), and North Pacific Gyre Oscillation (NPGO) events. These, combined with ongoing human-caused climate change and continued lack of recovery of multiple top trophic-level consumers in the system, indicate potential effects of climate on the productivity and other processes contributing to the function and composition of NP and BS food webs. We analyzed the bulk stable isotope values from annual growth layers drilled from archived juvenile male northern fur seal teeth along with compound-specific isotope analysis (CSIA) of individual amino acids (AA) from the same layers from a subset of seals to examine variability in their trophic position (TP), the overall food chain length (FCL), and other biogeochemical parameters in the NP and BS from 1946 to 2014. We targeted CSIA-AA of tooth layers grown in years that encompassed known climate variations in the NP and BS and we related oceanographic and isotope data to better understand how environmental conditions contribute to variation in ocean biogeochemistry and animal foraging patterns. Preliminary analyses of a subset of our data spanning 1946-2014 indicate minor changes in fur seal TP (3.3 to 4.0; $3.7 \pm \text{SD } 0.2$) over that time as estimated using the multi-TDF equation for seals from Germain et al. (2013). We also saw small changes in FCL ($\Delta^{15}\text{N}$, 13.9 to 15.8‰; $14.4 \pm \text{SD } 0.48\%$) as estimated by subtracting the average source amino acid $\delta^{15}\text{N}$ values from those from the trophic amino acids. However, the longest estimated FCL ($15.8 \pm 0.71\%$) corresponded to anomalously high ENSO and NPGO events in 1998, which is expected as food chain length becomes longer with warmer sea surface temperatures due to reduced nutrient availability and resulting dominance of smaller phytoplankton at the base of the food web. This also coincided with notable reductions in seal pup counts. Our data demonstrate the unique ability of bulk SIA and CSIA-AA analyzed from biologically inert tissues to recreate food web patterns in marine systems over time.

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Microbial isotope ecology
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Examining the role of gut microbes in host protein metabolism: linking microbial community composition with amino acid $\delta^{13}\text{C}$ analysis

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Recent research has found that intestinal microbiota perform many functions for their host, but among the most important is their role in metabolism, especially the conversion of biomass that the host is unable to digest into bioavailable compounds. Most studies have focused on the assistance gut microbiota provide in the assimilation of carbohydrates, however, the role they play in amino acid metabolism is poorly understood but is likely important for herbivores and omnivores faced with seasonal or persistent dietary protein limitation. To explore this topic, we conducted a controlled feeding experiment on mice (*Mus musculus*) in which we varied the relative amount and carbon isotope ($\delta^{13}\text{C}$) value of dietary protein and carbohydrates. We then used amino acid $\delta^{13}\text{C}$ analysis and genetic sequencing to quantify (1) the composition and relative abundance of gut microbiota among dietary treatments, and (2) the contribution of carbohydrate carbon used by the gut microbiome to synthesize essential amino acids used by mice to build muscle. We found that the relative abundance of *Firmicutes* and *Bacteroides* in mice ceca inversely varied as a function of dietary macromolecular content. *Firmicutes* and *Bacteroides* were equally abundant in the ceca of mice fed the high protein (40%) diet, but abundance of *Firmicutes* increased to >90% as the ratio of dietary carbohydrate:protein increased to ~75:5%. Mixing models utilizing amino acid concentration and isotope data estimated that the microbial contribution to the essential amino acids in mice muscle varied from <5% (threonine) to ~60% (valine) across diet treatments, with generally higher microbial contributions in the muscle of mice fed low protein (5%) diets. Our results show that intestinal bacteria are a significant source of essential amino acids that are used by their host organism to synthesize structural tissues. The role that gut microbiota play in the amino acid metabolism of wild animals that often consume protein deficient diets is likely a significant but currently under-recognized aspect of animal foraging ecology and physiology.

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Microbial isotope ecology
Oral presentation Tuesday 31 July 2018

Nitrate assimilation in aposymbiotic corals

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Corals are often limited by nitrogen. Different species have evolved a diversity of mechanisms to obtain and recycle this limiting nutrient, including symbiosis with different microbes. For instance, in light-abundant tropical reefs algal symbionts (*Symbiodinium*) can take up inorganic nitrogen and translocate it to the coral host. Corals that lack algal symbionts (aposymbiotic) are often characterized as living sediment traps that feed solely on particulate organic matter. Certain deep sea hard (calcifying) corals, however, host other microbial partners that can access inorganic nitrogen. We investigated the role of the microbial communities in nitrogen assimilation in four species of shallow water aposymbiotic proteinaceous corals. To determine if three species of soft coral (*Echinogorgia* sp., *Echinomuricea* sp., and *Menella* sp.) and one species of black coral (*Antipathes* sp.) can assimilate nitrate, we exposed colony fragments to 11.6 micromolar nitrate in an isotope tracer experiment both with and without antibiotics (12 mg/L doxycycline). We further assessed the putative role of microbes in nitrogen assimilation by characterizing the bacterial microbiome of each coral with 16S rDNA amplicon sequencing. Our results demonstrate that nitrate was incorporated into coral tissue and that differences in uptake across species align with differences in associated microbial communities. These results show that inorganic nitrogen can be used by aposymbiotic soft and black corals, expanding the taxonomic breadth of this feature across the Anthozoa. The prevalence of communities dominated by these corals suggests that they may play a significant role in nutrient cycling. Future work should focus on identifying which associated microbes are actively assimilating nitrate with transcriptome analysis.

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Plant isotope ecology

Oral presentation Tuesday 31 July 2018

A multi-element stable isotope natural abundance approach indicates partial mycoheterotrophy for Central European *Equisetum* species.

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Introduction/Aim: Nowadays, ~15 *Equisetum* species represent the last opportunity to study the ancient Equisetopsida (horse-tails) ecology and mycology. Equisetopsida evolved during the Devonian, had their species richness and abundance peak during the Carboniferous, but suffered from the Permian-Triassic extinction event. Equisetopsida fossils inform about their impressive 15-m height contrasting with much smaller living representatives (0.1-4 m). Despite their remarkable belowground biomass limited knowledge exists for ecological interactions with fungi. Fungal root endophytes are known to be either mutualistic, represented by a bi-directional nutrient exchange between the plant and the fungus (mycorrhizas), or antagonistic (mycoheterotrophy) where the plant exploits the fungus for carbon-nutrients. Obviously, achlorophyllous plants, unable to perform photosynthesis, must exploit their endomycorrhizal partners for achieving carbon supply. Interestingly, the stable isotope approach turned out as useful tool to unmask not only achlorophyllous, but also green plants as gaining carbon from their fungal partners. We aimed to evaluate fungal partners (microscopy, DNA-analysis) and the mycoheterotrophic status applying a stable isotope approach for the last recent representatives of the Equisetopsida.

Materials/Methods: Leaves of six *Equisetum* species and fully autotrophic co-occurring plants (FAP) were collected in Germany. Carbon and nitrogen stable isotope natural abundances and element concentrations were analysed. Additionally, for *E. palustre* and *E. sylvaticum* and their FAPs hydrogen and oxygen stable isotopes were measured. DNA-analysis for fungal endophytes is in progress.

Results: *Equisetum* microphylls turned out as enriched in ¹³C and ²H compared to FAPs, achlorophyllous *E. arvense* stems were equally ¹³C-enriched as achlorophyllous arbuscular mycorrhizal plants. *Equisetum* were mostly more enriched in ¹⁵N and had higher nitrogen concentrations than FAPs. **Discussion:** The isotope abundance and nitrogen concentration patterns found for *Equisetum* are similar to those found for green orchids identified as partially mycoheterotrophic gaining carbon from their fungal partners. Thus, *Equisetum* should be considered as new clade of partial mycoheterotrophs while achlorophyllous stems may be fully mycoheterotrophic. During the era of the Carboniferous coal forests, 30-m-tall scale bark trees overtopped 10-m-tall *Equisetum* ancestors. The potential of mycoheterotrophy could explain their carbon gain under these light-limited conditions. *Equisetum* ancestors were potentially the first green-leaved partially mycoheterotrophic plants on earth.

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Plant isotope ecology

Oral presentation Tuesday 31 July 2018

Wood Analysis: advances in bulk analytical techniques and considerations on accuracy of isotope ratio determination

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Nitrogen and sulfur are taken up from trees as nutrients. Their isotopic signature can be used to gather information on the source of these nutrients e.g. in ecological studies about N or S inputs into forests. Sources of S can be either natural or anthropogenic i.e. from air pollutants as SO₂ from fossil fuel burning. Sources of N inputs can be fertilizers and/or anthropogenic depositions. The determination of variations of ¹⁵N/¹⁴N ratios or ³⁴S/³²S ratios in environmental monitoring allows detection and quantification of these inputs. Furthermore, stable isotopes can also be used for tracing the geographical origin of timber thus helping to detect fraud in timber trade. The more isotopes are measured the better distinguishable are geographical sources. As N and S contents in wood are small while C contents are usually high, analytical techniques that can cope with this challenge are sparse. In general, elemental analyzers are used to gain isotope information on the bulk sample. Elemental analyzers are able to separate combustion derived simple gases by gas chromatographic columns and subsequent isotope ratio determination in a mass spectrometer. To overcome the difficulties with column overload of high CO₂ amounts derived from combustion, S can be extracted as BaSO₄ or Ag₂S and analyzed separately for δ³⁴S. In our presentation we show simultaneous NCS isotope analysis of wood by EA-IRMS and discuss the possibilities and restrictions of high C/S and C/N ratios. We compare δ³⁴S data from bulk wood to δ³⁴S from the extracted S as BaSO₄ and Ag₂S precipitates with respect to limitations in accuracy due to lack of standard material and possible mass interferences in analytical detection by mass spectrometers.

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Plant isotope ecology

Oral presentation Tuesday 31 July 2018

Stable isotopes elucidate more and more facets of mycoheterotrophic carbon gain among plants

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In the mycorrhizal symbiosis plants usually exchange photosynthates for mineral nutrients acquired by fungi. This mutualistic arrangement has been subverted by plants producing dust seeds and relying on fungal hosts for carbon supply in the seedling development stage (initial mycoheterotrophs). A few hundreds of initially mycoheterotrophic plants from at least 17 plant families remain achlorophyllous as adults and continue relying on fungal carbon (full mycoheterotrophs). Fully mycoheterotrophic plants are either mycorrhizal with fungi simultaneously forming arbuscular or ectomycorrhizas with forest trees or with wood or litter decaying saprotrophic fungi. During the last decade additionally an increasing number of green plants has been identified as gaining carbon simultaneously from two sources, own photosynthesis and mycorrhizal fungi (partial mycoheterotrophs). Here we aim separating mycoheterotrophic plants not only according to their respective functional groups, but also according to their taxonomic relationships and to the functional groups of their fungal hosts. We built up a stable isotope abundance database ($d^{13}\text{C}$, $d^{15}\text{N}$, $d^2\text{H}$, $d^{18}\text{O}$) of mycoheterotrophic and accompanying autotrophic plants and of molecular data on the identity of the mycorrhizal fungi to test the different functional groups for significance of differences in their isotope abundance patterns. Based on these multi-element stable isotope abundance data, we succeeded in statistically separating fully mycoheterotrophic plants associated with ectomycorrhizal, arbuscular mycorrhizal and wood or litter decaying fungi from each other and from autotrophic plants. We furthermore distinguished partially mycoheterotrophic plants from autotrophic plants and from full mycoheterotrophs and succeeded in separating partial mycoheterotrophs mycorrhizal with ectomycorrhiza-forming basidiomycetes and ascomycetes. A set of green orchids mycorrhizal with fungi of the polyphyletic rhizoctonia group was elucidated as partially mycoheterotrophic. Furthermore, we differentiated fully and partially mycoheterotrophic plants mycorrhizal with the same guild of fungi, but belonging to two different plant families (Orchidaceae and Ericaceae). We conclude that stable isotope natural abundance is an ideally suited tool to elucidate fungus-to-plant carbon fluxes and to identify functional diversity among mycoheterotrophic plants. Our results demonstrate that mycoheterotrophy in mycorrhizal symbioses is much more widespread and diverse than previously assumed.

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Physiology and biochemistry

Oral presentation Tuesday 31 July 2018

Amino acid-specific $\delta^{15}\text{N}$ trophic enrichment factor in fish fed with formulated diets varying in protein quantity and quality

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Compound-specific isotope analysis of amino acids (AAs) in consumer tissues is a developing technique with wide-ranging applications for identifying nitrogen sources and estimating animal trophic level. The approach relies on the measurement of the isotopic composition of the source and trophic AAs. One of the premises for applying a CSIA-AA approach is the robust estimation of the isotope discrimination between specific AA and a heterotrophs' diet. Recent meta-analysis indicate that trophic enrichment factors (TEFs) can vary as a function of dietary composition. Few studies have independently evaluated the effect of protein quantity and quality (digestibility) on TEFs, which complicates the application of AA- $\delta^{15}\text{N}$ values for estimating precise trophic levels. We conducted a 98-d feeding experiment using five formulated isoenergetic feeds prepared with a single high-quality protein source to evaluate the effect of protein quantity and quality on TEFs of liver and muscle tissues of juvenile Pacific yellowtail (*Seriola lalandi*), a carnivorous fish species. Fish grew well on all diets, with higher growth rates in diets with higher protein content. TEF_{bulk} showed a limited but significant relationship with protein quality in liver tissue, but did not differ with protein quantity nor quality in muscle. We show that protein quantity and quality influence isotope discrimination depending on the AA and tissue type, probably due to tissue-specific energetic requirements and metabolism. None of the pre-established source AAs varied with protein quantity or quality in liver tissue. For muscle, no significant differences were observed for source AA with changes in protein quantity, but Phe differed in response to decreased digestibility. For the set of the so-called trophic AA, only Leu varied as a function of protein quantity in liver tissue. In muscle tissue, Glu, Leu and Ile varied with dietary protein quality. Our results support the use of the isotopic composition of liver tissue as robust source and trophic amino acids. Some AA in muscle tissue (Phe, Glu, Leu and Ile) may be more sensitive to variations in dietary protein quantity and quality, and may not serve as proxies for baseline isotopic values or trophic level.

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Amino acid $\delta^{13}\text{C}$ analysis reveals trophic plasticity in a common reef-building coral

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The trophic ecology of reef-building corals has important implications for the persistence of coral reef ecosystems in an era of rapid environmental change. The endosymbiotic microalgae of tropical scleractinian corals are often considered the predominant source of coral nutrition. Yet most corals are also voracious predators and heterotrophic nutrition can enhance their survival, especially following physiological stress. Due to logistical challenges and a lack of *in situ* data, the importance of heterotrophic nutrition at community and ecosystem scales has likely been underestimated. Notably, the intricate recycling of carbon and nitrogen within the coral-algal symbiosis confounds interpretation of bulk coral tissue carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope values and has hindered the application of isotope analysis to study coral physiology and trophic ecology.

Here, we used $\delta^{13}\text{C}$ analysis of individual amino acids ($\delta^{13}\text{C}_{\text{AA}}$) to disentangle auto- vs. heterotrophic nutrition in a common coral. We sampled the branching coral, *Pocillopora meandrina*, from 4 fore reef sites ($n=3$, 10 m depth) on Palmyra Atoll in the central Pacific Ocean. The primary heterotrophic sources of nutrition, zooplankton ($n=8$) and particulate organic matter ($n=8$), were collected at each site as well as within the atoll lagoon to capture all potential variation in particulate food resources around Palmyra. We measured $\delta^{13}\text{C}$ values of 6 non-essential and 6 essential amino acids in both the (heterotrophic) animal and (autotrophic) endosymbiont fractions of coral samples. We then used a multivariate analysis of essential amino acid $\delta^{13}\text{C}$ values to classify autotrophic and heterotrophic sources of nutrition into discrete groups.

Coral animal essential $\delta^{13}\text{C}_{\text{AA}}$ values exhibited high spatial and inter-colony variation relative to the endosymbiont values, indicating marked differences in the incorporation of heterotrophic carbon among colonies across small spatial scales. $\delta^{13}\text{C}$ values of essential and non-essential amino acids in the animal and endosymbiont fractions of individual colonies were poorly correlated, further suggesting this coral does not rely explicitly on autotrophic nutrition. Collectively, our results provide a novel isotopic framework based on coral $\delta^{13}\text{C}_{\text{AA}}$ that will aid in the interpretation of bulk tissue $\delta^{13}\text{C}$ data and stimulate new studies of coral physiology and trophic ecology at broader spatial and temporal scales.

Advancing physiology: a single-sample method to measure the metabolic water contribution to animal body water

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Water flux and metabolic rate are critical aspects of animal physiology and ecology yet are difficult to assess in free-ranging individuals. Here, we demonstrate a novel method to estimate these variables via analysis of $D^{17}O$, a measure of $\delta^{17}O$ relative to $\delta^{18}O$ in a single sample of body water, distilled from blood serum or plasma. Body water is primarily a mixture of meteoric (i.e., drinking and food) water ($D^{17}O = 0.03 \pm 0.02$ per mil) and metabolic water synthesized from atmospheric oxygen ($D^{17}O = -0.45 \pm 0.01$ per mil); these $D^{17}O$ values are essentially constant over a wide range of $\delta^{18}O$ values. As a result, the $D^{17}O$ of animal body water ($D^{17}O_{BW}$) reflects changes in the rate of input from these two sources. Elevated metabolic rate increases metabolic water production, which should cause $D^{17}O_{BW}$ to decline towards the value of atmospheric oxygen. Supporting this prediction, we found that the $D^{17}O_{BW}$ of a variety of mammals from mice to elephants decreased with body mass, consistent with an increase in mass-specific metabolic rate. In addition, substantially increasing the intake of meteoric water should cause $D^{17}O_{BW}$ to increase towards the value for meteoric water. Accordingly, after accounting for body mass, $D^{17}O_{BW}$ tended to be higher for mammals from more mesic environments (i.e., those with greater availability of drinking water). This new tool has far-reaching potential applications. Currently, the only method to assess water flux and metabolic rate in free-ranging animals is using doubly-labeled water, which requires a long handling period at capture to allow equilibration of injected water, as well as a second capture within a short timeframe of days. These limitations are prohibitive for large or cryptic species but are avoided with our single-sample method. In addition, it may be possible to infer $D^{17}O_{BW}$ from organic tissues (e.g., fur or collagen), raising the prospect of estimating metabolic rate integrated over a variety of timescales from archived tissues or samples collected non-invasively. Our approach also provides an estimate of the $\delta^{18}O$ value of ingested water, which could provide a new tool for tracking animal movements and reconstructing the oxygen isotope composition of past precipitation.

PLENARY THURSDAY 2 AUGUST 2018 09:00 - 10:00.

Using ecological theory to maximise information recovery from stable isotope data.

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Statistical models in general have a tendency towards describing data and the systems they represent in rather phenomenological ways, with the ultimate insult being that they are mere “hand waving”. Stable isotope data represents the culmination of various environmental, physiological and ecological processes and ultimately our aim is to say something much more mechanistic about our systems than more descriptive statements such as: this dataset of isotope values is different to this one. A rich body of ecological theory exists that we can use to simulate basic processes of foraging ecology and food-web dynamics and so potentially ask how much of this process level information can we recover from stable isotope data with a goal being to maximise the recovery of the relevant information. By building more process driven models we can be more certain about our statements, and better understand when stable isotopes will be useful and when they might be confounded by multiple potential processes. This talk will focus on the ecological processes of niche width, specialism / generalism and food-web dynamics and the patterns they create in stable isotope data.

Do "tongue-biters" bite their hosts? The use of stable carbon and nitrogen isotope analyses to describe the foraging strategies of fish parasitic cymothoid isopods with respect to attachment site

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Cymothoid isopods are well-known marine fish parasites as they are large (usually > 20mm) and externally attaching. Among the cymothoids are those that infest and attach to the mouth, gill chamber, or body surface of hosts. The conspicuous attachment sites of these parasites and the damage they cause to hosts have led to widespread assumptions that these parasites eat the host tissue to which they attach. Yet, the life cycle and infestation behavior of cymothoids do not support this assumption. First, cymothoids are protandric hermaphrodites. Males feed until they have molted into sexually mature females, and females likely do not feed during brooding. Secondly, despite the similar mouth and leg morphology of cymothoids, only body surface-infesting parasites seem to continually pierce their host with their mouthparts. Accordingly, we expect the foraging strategies of parasites to differ by gender, and that there are differences in foraging strategies and nutrient uptake across parasites in relation to where they attach to their host. To test these predictions, we conducted stable carbon and nitrogen analyses of fish muscle, scale, gill, and heart tissues, and compared these to female and male parasite leg tissue. Body surface, gill chamber and mouth-infesting parasites and their hosts were represented by *Anilocra haemuli* infesting *Haemulon flavolineatum*, *Mothocya affinis* infesting *Hyporamphus affinis*, and *Cymothoa sodwana* infesting *Trachinotus botla*, respectively. We determined that across genera, male parasites were significantly depleted in ¹³C compared to female conspecifics. Males infesting the mouth and gill chamber were significantly enriched in ¹⁵N as compared to female conspecifics, yet body surface-infesting females were significantly enriched in ¹⁵N as compared to male conspecifics. Generally, attachment site significantly influenced the difference in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ between hosts and parasites across tissue types and by parasite gender. Compared to hosts, parasites were enriched in ¹⁵N from 0.09 -2.23‰, and their $\delta^{13}\text{C}$ values fell inside and outside the hosts range. These findings provide evidence that energy assimilation (inferred from ¹³C and ¹⁵N) varies by cymothoid gender and attachment site, and nutrition for certain cymothoid species and/or life stages of the same species may not be limited to host tissue.

Financial assistance for RL Welicky from the Claude Leon Foundation of South Africa and North-West University is acknowledged. Stable isotope analysis/training support for HM Strauss was provided by University of Duisburg-Essen, UID 105875 under the project, "Novel approaches to assess toxicity of platinum-group elements in aquatic environments (PI: Smit)".

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Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Macrofauna as vectors of seagrass organic matter transfer in *Posidonia oceanica* macrophytodetritus accumulation

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Seagrass ecosystems are net autotrophic systems which contribute to organic carbon burial in marine sediment. Dead seagrass leaves are often exported outside the seagrass beds and may form accumulation (exported macrophytodetritus accumulation, hereafter EMAs) from littoral to deepest canyons. To understand how seagrass organic matter is fueled in associated trophic web is necessary to assess the role of seagrass ecosystem as blue carbon service providers. We used gut content and stable isotope analyses to delineate the *Posidonia oceanica* EMAs food web structure and to determine the importance of detrital material in the diets of the macrofauna. Evidence from gut contents and stable isotopes (SIAR modelling) showed that this food web is fueled mainly by 2 food sources, found in the detritus accumulations: 1) *P. oceanica* detritus it-selves and 2) epiphytes and drift macroalgae. Dead leaves of *P. oceanica* entered in the diet of dominant species, representing more than 60% of animal abundance. Using Bayesian modelling, we showed that the food web is structured in five trophic levels with a numerical dominance of detritivore/herbivore species at first consumer level. Animals act as vector of seagrass organic matter to upper trophic levels and this “dead seagrass signal” is followed through the entire food web. Seagrass primary production and seagrass organic matter processing by animals are therefore spatially decoupled and this should be taken into account in assessment of seagrass ecosystems as key actor of C cycle in coastal areas.

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Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Estimating contributions of pelagic and benthic pathways to consumer production in coupled marine food webs

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A key goal in ecological research is to determine mechanisms which influence ecosystem stability. In marine ecosystems, differences in production dynamics of pelagic and benthic detrital pathways likely influence the stability and productivity of the consumers they support. Improving understanding of how consumers utilise these pathways can help ascertain ecosystem resilience to human and environmental perturbations. Diet studies may demonstrate the extent to which consumers feed on prey in pelagic or benthic environments. But they do not discriminate benthic production directly supported by phytoplankton from benthic production recycled through detrital pathways. We develop and apply a new analytical method that uses bulk carbon (C) and sulphur (S) natural abundance stable isotope data to assess the relative contribution of pelagic and benthic pathways to fish consumer production in the northern North Sea. For 13 species of fish that dominate community biomass, use of pelagic pathways ranged from less than 25% to more than 85%. Use of both C and S isotopes as opposed to just C reduced uncertainty in modal use estimates. Temporal comparisons of modal use of pelagic and benthic pathways revealed similar ranking of species dependency over four years, but annual variation in modal use within species was typically 10-40%. Total fish consumer biomass in the study region linked approximately 70% and 30% of biomass to pelagic and benthic pathways respectively, suggesting a substantial proportion of fish biomass is supported by production that has passed through transformations on the seabed. All sampled species appear to use both pelagic and benthic pathways to some extent, potentially providing a more resilient feeding strategy, stabilising the food web and increasing ecosystem resilience.

NERC (NE/L008718/1) and the UK Department of Environment, Food and Rural Affairs (project MF1225 Integration of environmental and fisheries management)

HT639TT

Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Trophic interactions of deep-sea (200-3,000 m) benthic fauna identified from compound specific stable isotope analysis of amino acids

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The deep-sea benthic food web in the Great Australian Bight (GAB) off southern Australia was analysed for the first time as part of a research program to increase knowledge of the poorly understood benthic ecosystems in the region. Compound specific stable isotope analysis of individual amino acids was used to evaluate trophic position in a cross-section of prominent deep-sea taxa and abundant species that represent a variety of feeding guilds (e.g. detritivores, micronektivores and piscivores) against two hypotheses: the deep-sea GAB is characterised by (1) a conventional surface-driven hierarchical food web with recognised feeding guilds of benthic animals showing isotopic enrichment (isotopic fractionation) of trophic amino acids and relatively little enrichment of source amino acids leading to a relatively low amino acid trophic position or (2) a more confused, less hierarchical food web with more variable trophic position and poorer diet quality (depleted levels of essential amino acids) driven by a mixture of material that originates from a variety of pelagic sources, some of which is heavily re-worked (i.e. consumed multiple times). We found many species with elevated trophic positions and a non-hierarchical food web consistent with Hypothesis 2. There were no clear patterns or trends in trophic position corresponding to feeding guilds across the broad spectrum of taxa, and all guilds were represented by some species with relatively high and low median trophic position. Similarly, there were no clear patterns or trends in trophic position within or between taxonomic groups. Thus, there was high variation of trophic position between decapods, and no differences in groups where this would have been predicted based on feeding guild, e.g. macrourids, all consistent with the notion of a high degree of opportunistic feeding. There was no consistent trend with depth or longitude, although the shallowest samples (combined upper slope and shelf edge in depths <450 m) are significantly different from deeper samples. This appears to indicate less reworking, and shorter food chains.

The Great Australian Bight Research Program: collaboration between BP, CSIRO, the South Australian Research and Development Institute (SARDI), the University of Adelaide, and Flinders University. The Program aims to provide a whole-of-system understanding of the environmental, economic and social values of the region; providing an information source for all.

JD316QP

Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Insights from compound-specific isotope analysis into the nutritional ecology of herbivorous reef fishes

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Herbivorous coral reef fishes play key roles in helping to structure their environment directly by consuming algae and indirectly by promoting coral health and growth. These fishes have traditionally been classified as functionally redundant groups: browsers, grazers, and excavators/scrapers. However, recent observational and morphological evidence questions the use of this broad classification scheme, and posits that there may be more resource partitioning within these functional groups than previously assumed. To test this hypothesis, we analyzed stable carbon isotope ratios of essential amino acids ($\delta^{13}\text{C}_{\text{EAA}}$) of herbivorous coral reef fishes and their potential food resources, including corals, macroalgae, detritus, and phytoplankton, from a Red Sea coral reef. Using a multivariate statistical approach, we found distinct $\delta^{13}\text{C}_{\text{EAA}}$ patterns among the different potential food sources from each other. This further demonstrates the utility of $\delta^{13}\text{C}_{\text{EAA}}$ analysis as a robust way at determining fine scale differences in the isotopic baselines of marine food webs. Most fishes within each functional group also had distinct $\delta^{13}\text{C}_{\text{EAA}}$ patterns. We found that within the grazer group, different species $\delta^{13}\text{C}_{\text{EAA}}$ values differed from other grazers. Their highly differential nutritional ecology and targeting of different foods implies a low level of functional redundancy within this group. Scraping parrotfish were distinct from excavating parrotfish and to a lesser degree different among each other. Food samples appear to be used distinctly in different combinations by fishes within and between functional groups as well. These results question the utility of lumping nominally herbivorous fishes into broad functional groups with assumed similarity in functional roles. Given the apparent functional differences between nominally herbivorous reef fishes, it is imperative for managers to consider the diversity of ecological roles each of these fishes play as important parts of productive coral reef ecosystems, especially given these functional and nutritional differences.

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PR477PD

Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Aliens vs. Fish: An invasive asian mussel (*Limnoperna fortunei*) alters food webs, and trophic niche in native fish species that partially limit their abundances.

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Since the invasive Asian golden mussel (*Limnoperna fortunei*) was first reported in Rio de la Plata in the 90s it has continuously expanded thorough South America, promoting several negative ecosystem consequences. While this mussel has been reported as prey for several fish species, these interactions and its food web consequences have not been studied. Combining data from 12 years of fish and *L. fortunei* abundance monitoring with present-day and historical (pre-invasion) analysis of diet composition and of stable isotopes of carbon and nitrogen, we aim to determine the potential role of fish as controls of *L. fortunei* abundance, and the food-web and species niche consequences of this invasion in lower Uruguay River. One third of the fish species in the assemblage (22 species) consumed *L. fortunei*, being a dominant item (>20% of the dietary volume) in 12 of these species. Consistently, stable isotope mixing models suggest that > 14 % of total fish assemblage biomass derives from *L. fortunei* tissues in the present. Along the monitored period, with increased abundances of fish species predated *L. fortunei* the abundance of this mussel decreased. The same relationship applies when only considering abundance of boga (*Megalporinus obtusidens*), a fish species consuming > 80% of *L. fortunei* in its diet. The analysis of historical samples of the two greater *L. fortunei* consumers (*M. obtusidens* and *Pimelodus maculatus*) revealed a reduction in direct terrestrial subsidies and vegetal matter as fish started to incorporate *L. fortunei*, after the invasion. This dietary shift provoked changes in dietary and isotopic niche towards an increased trophic position and reduced trophic diversity, diversity of food consumed and generalism in *M. obtusidens*. This reported predator-prey interaction may allow predicting food web changes in newly invaded areas. Native fish are key natural predators of this pest that could be used as partial bio-control measure in certain scenarios; however, preservation of native communities seems the best strategy to mitigate some of worst ecological consequences of the invasion.

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Sectorial Commission for Scientific Research (CSIC) Project CSIC I+D_2016_577348

KR282MS

Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

The forgotten dimension: how important is time to isotope ecology?

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Stable isotopes are being increasingly used to quantify community-level metrics of structure and function, scaling up from individuals to broad levels of biological organisation. Throughout these approaches, such as estimating predator-prey mass ratios, fine-scale temporal variation is neglected for the sake of the increased sample sizes required. In temperate ecosystems, strong seasonal fluctuations in the relative abundances and isotopic compositions of primary production sources likely impart variability on community metrics, however the degree to which this temporal variability is captured by isotopic data is poorly resolved. We address this knowledge gap by measuring stable isotope compositions of individuals representatively sampled from a dynamic estuarine fish community, at monthly resolution over a full annual seasonal cycle, coupled with plankton samples and environmental data. Across the fish community, both carbon and nitrogen isotope ratios showed significant monthly variation after accounting for species and size effects. Sudden decreases in May, coinciding with the peak in the spring phytoplankton bloom were followed by remineralisation through the autumn and winter months. These trends were corroborated by similar trends in water nitrate levels and show that changes in the isotopic compositions of basal production fuelling the food web are rapidly expressed in higher trophic levels, despite relatively slow tissue turnover rates. Sulfur ratios separated out functional groups but a lack of any temporal trends suggest that relative contributions of pelagic and benthic production sources remain constant throughout the seasonal cycle. Utilising *in situ* estimates of the individual size spectrum, we further explore trends in the predator-prey mass ratios over the seasonal cycle. This research suggests that community level metrics, as inferred from stable isotope analyses, can exhibit strong temporal dynamics, and that time should be considered when comparing these metrics within or between different systems.

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Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Temporal food web changes in Greenland's priority marine conservation regions: Insights from bulk and compound-specific stable isotopes and fatty acids

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Several Greenlandic ecoregions have recently been proposed for adoption under the UNESCO's World Heritage Convention due to their critical value in safeguarding high biological activity and diversity. Nonetheless, these ecoregions have been subject to ongoing rapid change in sea ice dynamics. We will present results of long-term studies to determine changes in the food webs of four candidate heritage sites, the Northwater (NOW), Northeast Water (NEW) and Scoresby Sound (SCO) polynyas and the Disko Bay (DISKO). We have been compiling both bulk stable isotope and fatty acid data from a variety of sampling campaigns, spanning research cruises since the 1990s as well as long-term monitoring initiatives such as the Arctic Monitoring and Assessment Programme. Our results indicate that seabird species using the NOW polynya have changed their isotopic niche and have declined in trophic position compared to the late 1990s as also observed for DISKO seabird species in both recent and earlier years. While the time series for black guillemot *Cephus grylle* and ringed seal *Pusa hispida* indicate trophic position and niche size variation among years, data support a general decline in trophic position. Furthermore, a time series of SCO polar bear *Ursus maritimus* shows recent change in their diet from being dominated by ringed seal to increasingly comprising hooded seal *Cystophora cristata*. Our results on spatiotemporal variation in bulk stable isotope and fatty acid ecology will be complimented by our first data on stable isotope values in consumer amino acids. Finally, we will outline how all data will holistically feed into an ecological network analysis framework.

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Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Integrated stable isotope approaches to full salmon life history analysis

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Pacific salmon have extremely complex life histories that span both freshwater and marine environments. The marine phase alone includes estuaries, coastal waterways, continental shelf and the high seas. Resolving salmon ecology across these diverse marine habitats is critical to understanding their response to rapidly changing ocean conditions. Food webs supporting salmon and their migration pathways are two interrelated aspects of salmon biology that are central to their marine survival. Food webs provide the essential nutritional support for growth, maturation and successful reproduction, and migration pathways determine the food webs that salmon encounter. However, direct measurement of food web dynamics and migration routes is extremely challenging logistically, and resource expensive. We have developed an integrated stable isotope approach that allows retrieval of detailed information on salmon life history across all marine phases. Here we outline this approach drawing on case studies from British Columbia, Canada. Bulk and compound specific analyses of tissue carbon and nitrogen stable isotopes provide insights into the trophic dynamics that underpin salmon food webs. Given soft tissues turnover rates of 1-6 months, stable isotope measurement of muscle tissue provide insights into the first months at sea of juvenile salmon, while tissues from returning adults inform conditions experienced on the high seas in the summer prior to spawning. Hard tissues (otoliths and scales) record information on trophic ecology over the entire lifespan of a fish. We use scale archives to reconstruct decadal changes in salmon trophic ecology in the north Pacific, while strong correlations between scale $\delta^{13}\text{C}$ and ocean temperature allow us to map the high seas distribution of salmon in relation to plankton measured by the north Pacific Continuous Plankton Recorder survey. Migration behavior is further informed by Laser Ablation Inductively Coupled Plasma Mass Spectrometry. We analyze the isotopes of multiple elements to determine the timing of marine entry, and subsequent juvenile migration and growth rates, and the migration pathways of post-juvenile salmon. Finally, we summarize the integrated food web and migration information to identify critical periods for marine survival during salmon's marine life history phase.

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Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Freshwater particulate organic matter and trophic webs in a riverine watershed

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Our results from high-resolution spatial and temporal analyses of suspended particulate organic matter (POM) from the Cosumnes/Mokelumne river watershed in California's Sacramento-San Joaquin Delta, during a high rainfall year, were highly variable in terms of C and N isotopic composition. The isotopic composition of POM was consistently correlated to both river discharge and water temperature, emphasizing the role of local water chemistry and river conditions in determining POM isotopic compositions. This variability, however, obviates the application of bulk analysis for discerning the qualitative and quantitative sources of OM comprising POM and the degree to which POM fuels secondary production. Therefore, we expanded upon this work by measuring compound specific isotope compositions of amino acids in our freshwater ecosystem, including higher plants, POM, zooplankton, and fishes to determine the relative contribution of allochthonous and autochthonous organic matter to the food web.

A comparison of the $\delta^{13}\text{C}$ of amino acids in POM and higher plants confirms that POM in our riverine ecosystem does not resemble that of unaltered higher plants. The absolute range of $\delta^{13}\text{C}$ from higher plants (mean range= 34‰) was significantly greater than that measured in POM (mean range=23‰), which suggests algal or decomposed plant matter are more likely components of POM, similar to the findings of Kendall et al. (2001). One exception was a sample taken on an active floodplain, which had a range in $\delta^{13}\text{C}$ amino acids similar to terrestrial plants, indicative dynamic terrestrial-aquatic exchanges. Analyses of native and non-native, young-of-year fishes collected during water year 2017 were conducted to investigate possible differences in their resource utilization and trophic position. Amongst native and non-native fishes, amino acid $\delta^{15}\text{N}$ had a high degree of similarity and were more similar to those of zooplankton, rather than higher plants. Glu-Phe differences within fishes and zooplankton do not support the presence of an allochthonous source of nitrogen to consumers. Similarity amongst the nitrogen isotope compositions of consumers demonstrates the reliance of heterotrophs on a common set of resources. Overlapping resource utilization suggests that both the native and non-native fishes are competing for similar high-quality food items.

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NG427HP

Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

A positive relationship between plant height and leaf $\delta^{13}\text{C}$ at the species- and community-level in the Atacama Desert

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In arid environments, limiting resources can act as filters that modulate plant strategies, and ultimately lead to changes in community structure. The fast-slow plant economics spectrum hypothesis (fsESH) state that in areas with more water or nutrient availability, plants adopt a strategy of fast resource use, whereas in areas with less resource availability they adopt a slow resource-use strategy. Coastal desert shrub communities in the Atacama Desert are patchily distributed throughout the landscape. This spatial pattern can be linked to a heterogeneous distribution of soil resources, which in turn result from spatial variation in soil characteristics. We tested the fsESH at the species- and community-level by examining the relationship among key functional traits in four local communities in the Coquimbo Region (30°S) in Chile with similar climatic conditions, but located in different soil types. Our results revealed a significant and positive relationship between leaf $\delta^{13}\text{C}$ and plant height (a common trait used as a proxy of plant size) both at the species- and community level. This relationship is strongest at the community-level, indicating that soil can play a major role over the functional structure of plant communities. Leaf $\delta^{13}\text{C}$ values revealed that bigger plants have higher water-use efficiency and slower carbon assimilation rates. We found no relationship between leaf $\delta^{13}\text{C}$ and other leaf or root functional traits. Our results partly support the hypothesis that plant size is related to metabolic and growth rates, and ultimately with an acquisitive or conservative strategy.

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Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Global food web alteration following goldfish introduction in palmate newt dominated pond ecosystem

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Introduction of invasive species is one of the main threat to amphibians worldwide. Beyond direct predation or competition effects with native species, omnivorous invasive species are of particular concern as they can have important and long-term impacts on native populations by affecting the entire communities. In Larzac (Southern France), declining trends in the pond-breeding palmate newt (*Lissotriton helveticus*) populations are correlated to goldfish (*Carassius auratus*) introductions. However, the processes leading to local extinction of newts as well as other native organisms from invaded ponds are not fully understood. In particular, by destroying the aquatic vegetation, goldfish may have a strong impact on the pond ecosystem, potentially making it an unsuitable habitat for newts. To assess the impact of goldfish leading to newt extinction, we compared community assemblages and isotopic community niches of consumers in ponds naturally dominated by palmate newts and in ponds where newts have been extirpated following goldfish introduction, using various techniques including carbon and nitrogen stable isotope analysis in a Bayesian framework. We used recent developments in standardization methods to account for variation in isotopic composition of basal resources when comparing consumer food webs across multiple sites. Our results show that beyond direct interactions with newts, goldfish have profound detrimental impacts on the ecological communities of ponds by operating a global alteration of the food web on multiple trophic levels. Changes were characterized by a trophic downgrading, reduction in diversity and trophic redundancy, and the extirpation of almost all exploitable resources available for newts. In the long-term, these changes likely explain newts exclusion from invaded ponds and illustrate the complex detrimental effects of omnivorous fish introductions for native ecosystems.

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Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Trophic inferences of lionfish in the Colombian Caribbean from stable isotope analysis

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Currently, the invasive *Pterois volitans* is distributed in the Western Atlantic from the United States of America to Brazil, and from the Gulf of Mexico to Barbados. This widely distribution of the lionfish is having negative impacts on populations of native species, the structure of the food web and fishery resources; adding more stress to the already disturbed coral ecosystems. To better understand the impacts of these fishes, we analyzed the carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope composition from the muscle of 501 samples of *Pterois volitans* caught in two areas (Bolívar and Magdalena) from Caribbean Colombian in 2014 and 2015, using a continuous-flow system by means of an elemental analyzer combined with a Delta Plus XL mass spectrometer to describe their feeding ecology. Mean (\pm SD) muscle isotope values of the lionfish for Bolívar area were $-17.5 \pm 1.1\text{‰}$ for $\delta^{13}\text{C}$ (range between -20.7 to -14.0‰) and 10.6 ± 0.7 for $\delta^{15}\text{N}$ (range between 8.8 to 12.4‰). While the mean values for Magdalena area were $-16.5 \pm 1.0\text{‰}$ for $\delta^{13}\text{C}$ (range between -20.7 to -14.4‰) and 10.5 ± 0.5 for $\delta^{15}\text{N}$ (range between 9.2 to 12.0‰). These data suggest that the lionfish move between coastal and oceanic waters, foraging prey of with higher $\delta^{15}\text{N}$ values.

Universidad de Bogotá Jorge Tadeo Lozano. Proyecto Ecología y Biología del Pez León en dos Ambientes del Caribe Colombiano. Convocatoria No. 12 de 2015 de la Dirección de Investigación, Creación y Extensión.

PG695LJ

Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Local and oceanic inputs into the trophic ecology of two bivalve species in a coastal lagoon: evidences from stable isotope, fatty acid, and compound specific isotope analyses

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Coastal lagoon ecosystems play important ecological and economic roles, providing habitat to many resident and migratory species, and supporting fisheries of importance for local communities. At the interface between land and ocean, their productivity originates from both terrestrial and marine inputs, as well as from local processes. Suspension-feeding bivalves are major components of coastal lagoons and reflect, because of their feeding mode and sessile lifestyle, biogeochemical processes underlying ecosystem functioning. The Ojo de Liebre lagoon (Baja California, Mexico) is a 30 km long and 10 km wide lagoon facing the Southern California Current upwelling system. Although the lagoon lacks freshwater inputs owing to the arid climate, it supports one of the largest eelgrass (*Zostera marina*) beds in the Northeast Pacific. The trophic ecology of two bivalve species (*Nodipecten subnodosus* and *Spondylus crassiquama*) was studied seasonally and throughout their distribution range in the lagoon, using a multi-tracer approach combining stable isotope (SI), fatty acid (FA), and compound specific analyses (CSIA). The results highlighted seasonal and spatial patterns, with individuals from the entrance of the bay relying on ¹⁵N-enriched oceanic phytoplankton, including diatoms (FA biomarkers 20:5n-3 and 16:1n-7) after the upwelling season, while those located the furthest from the entrance of the bay appeared to rely on local production (FA biomarkers 18:3n-3, 18:4n-3, 18:1n-9), including the microbial food web (bacteria, flagellates). Based on SI, FA and CSIA analysis, no significant contribution of seagrass detritus to the diet of bivalves was found. During summer, the contribution of benthic organic matter, originating from local processes, in the diet of individuals inside the bay; as well as the role of oceanic inputs near to the mouth of the bay, was confirmed by CSIA on diatoms and flagellate markers. Overall, our results illustrate the spatial and temporal heterogeneity affecting the trophic functioning of such large coastal lagoons, where both oceanic inputs and local processes play a key role. Moreover, this study highlights the complementarity of the three analytical tools, where SI were able to track nitrogen fluxes, while FA and CSIA were more powerful to characterize the nature and the origin of food sources.

PG853GT

Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Intrapopulation variation in resource use by Kemp's ridley sea turtles revealed through combined skeletal and stable isotope analyses

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Intrapopulation variation in resource use can have strong effects on population and community dynamics, particularly in threatened and endangered species, whose populations are sensitive to small changes in vital rates. The endangered Kemp's ridley sea turtle (*Lepidochelys kempii*) exhibits high intrapopulation variation in somatic growth, but the drivers of this variation are not well understood. For example, growth rates are higher in juveniles that inhabit the Gulf of Mexico versus the U.S. Atlantic Coast, but whether this is due to differences in foraging ecology or environmental conditions remains unknown. Bulk stable carbon and nitrogen isotope analysis (SIA; $\delta^{13}\text{C}$, $\delta^{15}\text{N}$) can provide information on past diet and habitat use and can be used to identify the timing of resource shifts. When combined with the analysis of annually deposited tissues, such as turtle bones, SIA can provide life history information for multiple years into the past. Here we employ bulk SIA of humerus bone tissue to characterize variation in resource use within and among Kemp's ridley sea turtles throughout their ontogeny and range. Humerus bones were collected from turtles stranded dead on beaches along the U.S. Gulf ($n = 50$) and Atlantic ($n = 54$) Coasts. Two bone cross-sections were cut from each bone—one histologically processed to reveal annual growth layers, one sequentially sampled for SIA using a micromill. Within individual turtles, $\delta^{15}\text{N}$ values increased sharply (mean increase = 3.45 ‰) in the first one to three years of life, consistent with current understanding of Kemp's ridley life history, which presumes an oceanic-to-neritic resource shift by age two. Following this perceived shift, $\delta^{15}\text{N}$ values were consistent within individuals, but varied among individuals, suggesting individual specialization in resource use. $\delta^{15}\text{N}$ values were consistently highest in turtles that stranded in Texas and lowest in turtles that stranded along the Gulf Coast of Florida. Mean $\delta^{13}\text{C}$ values did not differ by age or stranding location. Ongoing analyses are working towards determining whether these isotopic patterns reflect differences in turtle trophic dynamics, biogeochemical cycling at the base of the food web, or both, and ultimately whether turtle trophic ecology influences somatic growth.

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Translocated top predator, the Tasmanian devil shows seasonal niche flexibility

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Captive-raised Tasmanian devils were translocated to an offshore devil-free island, Maria Island, as part of a species recovery program. The devil is a generalist predator/scavenger. Three years since the first release, the devil population is a mix of the original founders and their wild-born progeny. Here we identify how the devils diet changes seasonally within this novel environment and determine whether rearing style (captive-raised or wild-born) or age influenced the devils diet through the year. To reconstruct the diet of the different devil cohorts we used bulk $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of devil vibrissae. A single vibrissa ($n=53$ devils) was sectioned into an average of 9.7 ($\text{SD}=5.6$) segments. We had isotopic information over summer ($n=23$ devils), autumn ($n=51$ devils) winter ($n=43$ devils), and spring ($n=33$ devils). We used mixed models to determine what influenced changes in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values. To predict the devil's diet we used Bayesian mixing models, the devils whisker isotopic values along with isotopic values from their potential prey. Variation in devil $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values were influenced by the interaction between the devils' rearing style and age (captive-raised founders or wild born progeny) and the season in which their vibrissae grew. The captive-raised devils consumed lower trophic prey in winter compared to their wild-born progeny. Mixing models suggest that both groups of devils ate marine (seabirds) and terrestrial (geese and macropods) prey, but during the winter, where the founder devils switched to consuming mainly terrestrial prey, the wild-born progeny did not. We show that the devils show niche flexibility in their novel environment. Isotopic values suggest that the older, founder devils switch seasonally between marine and terrestrial food sources. This is consistent with prey availability on the island as the seabirds, the marine prey, leave the island in winter. It is surprising, however, that the isotopic values of the younger, progeny did not also suggest a diet switch to terrestrial prey. The range of prey available on the island is likely to have helped the devil adapt to their new environment.

PM136FK

Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Environmental parameters and biotic interactions influence chemosynthesis-based food webs supporting deep-sea cold seeps communities off West Africa

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Cold seeps are areas of the continental margins where emissions of methane and/or other hydrocarbon-rich fluids reach the seafloor. Through production of chemosynthetic micro-organisms, they support high biomass of benthic invertebrates. Despite their global distribution and increasing evidence of their interactions with surrounding ecosystems, environmental and biotic factors driving food web structure in deep-sea cold seeps are still unclear. Here, we aimed to delineate food webs supporting invertebrate communities at the Regab site, a large (800 m wide) pockmark featuring several biogenic habitats found at a depth of 3200 m in the Gulf of Guinea, off the coast of West Africa. Using stable isotopes of carbon and nitrogen and an isotopic niche approach, we examined trophic interactions among three habitat types: *Bathymodiolus boomerang* mussel beds, Vesicomidae bivalve clusters, and *Escarpia southwardae* tubeworm bushes. Targeted organisms included 17 taxa spanning multiple eco-functional guilds (symbiotrophs, bacterial grazers, detritus feeders and scavengers/predators). In mussel beds, the $\delta^{13}\text{C}$ of the symbiont-bearing *B. boomerang* and most associated animals was very negative, suggesting the assemblage predominantly depended on methanotrophy. Relative positions of the symbiotic polychaete *Branchipolynoe seepensis* and its mussel host were not consistent from one site to another, suggesting trophic plasticity in this polychaete whose feeding strategy is still unclear. Conversely, Vesicomidae bivalves and their associated fauna depended on thiotrophy. Isotopic niches of co-occurring vesicomids *Laubiericoncha chuni* and *Christineconcha regab* were distinct, suggesting resource partitioning. This partitioning could be habitat-based, as *L. chuni* possess morphological and ecophysiological adaptations allowing it to burrow deeper. *E. southwardae* tubeworms also depended on sulphide-oxidizing symbionts. $\delta^{13}\text{C}$ of *B. boomerang* mussels living attached to tubeworms were less depleted by over 10 ‰ compared to when they were living alone. These values are compatible with reliance on both methanotroph and thiotroph symbionts. This could suggest that tubeworms, besides the physical habitat they offer, could also modulate availability of chemical species for other organisms, reinforcing their status as ecosystem engineers. Overall, our results indicate that in the mosaic of micro-habitats offered by the Regab pockmark, food web structure was influenced by environmental parameters dictating resource availability, but also by ecological interactions.

PM534GP

Isotope ecology from individuals to communities II

Oral presentation Thursday 2 August 2018

Bulk & CSIA reveals the complex trophic ecology of ocean sunfishes, identifying global ontogenetic patterns

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Over the last 50 years, anthropogenic pressures have reduced oceanic megafaunal biomass by ~90%. Understanding the long-term consequences of this mass removal, however, is currently limited by a paucity of data to assess the complexity of marine food webs and the role of predators. Here stable isotope analysis (SIA) provides novel insight into the diet and trophic role of the ocean sunfish, a vulnerable predator that reaches ~3 m total length (TL) and weighs ~2.3 tonnes (*Mola mola*). Although sunfishes were historically described as obligate gelatinivores, recent research suggests that smaller specimens (~1m TL) have broader dietary niches, whereby individuals shift from high (e.g. ~18kJ/g) to low-energy (e.g. ~9kJ/g) density prey as they grow. Owing to their limited commercial value, sunfishes are poorly-studied with specimens relatively difficult to obtain. To prevent unnecessary sacrifice for SCA, in this study bulk tissue and amino acid (AA) analyses of opportunistically-collected freshly-stranded fishes and bycatch in the Mediterranean Sea (n = 22, 40:110cm TL), North Atlantic (n = 8, 67:215cm TL), and Pacific Oceans (n = 6, 39:94cm TL) were used to assess sunfish trophic ecology. Bulk tissue SIA of Mediterranean sunfishes shows a significant ontogenetic decrease in $\delta^{13}\text{C}$ (-3‰) and $\delta^{15}\text{N}$ (-2.5‰) values (40:97cm TL), consistent with a dietary shift from mixed nearshore prey to predominately pelagic, gelatinous taxa. These results were strongly supported by sunfish AAESS $\delta^{13}\text{C}$ data and AA $\delta^{15}\text{N}$ -based estimates of trophic level over a broad size-range globally (40:215cm TL), indicating a complex trophic role with differing feeding modes. The combination of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values also identified fish from different oceans basins, potentially enabling assessment of movement and population connectivity. CSIA has great potential to unravel the trophic ecology and habitat-use of wide-ranging consumers. When combined with supporting DNA analyses and crittercam footage, these data confirm that sunfish are not obligate gelatinivores but have a complex trophic role. As sunfishes are subject to target fisheries and high-bycatch (removing 100 000s individuals/yr), these data are highly significant, providing baseline ecological data to predict the potential consequences if the mass removal of this species continues and to facilitate species conservation management.

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Archaeology and Palaeoecology I

Oral presentation Thursday 2 August 2018

'Meat of the matter': the effects of seasonal selectivity, food storage, and tissue turnover rates on human paleodiet reconstructions

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Paleodiet studies using stable isotopes often utilize animal bone collagen carbon and nitrogen isotope compositions as proxies for dietary protein. Implicit in this approach is the assumption that meat - muscles, skin, blood, and internal organs - had isotopic compositions that were equivalent to those of bone, once tissue-diet discrimination factors are taken into account. However, meat has much more rapid turnover rates than bone, so its isotopic composition can vary seasonally in animals with seasonal diet shifts. This paper explores contexts in which bone collagen may be a poor proxy for the protein in ancient human diets. For example, in some C3-dominated areas of North America, small mammals increase CAM plant consumption during dry seasons, which could seasonally increase the C- and N-isotope composition of their muscles and organs. Analyses of ancient dung and bone collagen from the Promontory Caves archaeological site in northern Utah suggests that this may have occurred in the eastern Great Basin and should be accounted for in isotope-based paleodiet reconstructions. In many parts of the Great Plains and Colorado Plateau, large herbivores such as bison switch to high-C4 diets during the summer, which increases their C- and N-isotope values. Many Native American groups engaged in large-scale communal bison hunts in autumn and preserved bison meat for consumption in winter. This meat might have had significantly different isotopic compositions than would be expected based on bone collagen preserved at prehistoric kill sites. In Pleistocene Eurasia, it has been observed that Neandertals had very high N-isotope values, and Bayesian analyses using animal bone collagen as a proxy for dietary protein have concluded that Neandertal diets were high in mammoth meat. However, if mammoth meat N-isotope values varied seasonally and if Neandertals preferentially hunted during late autumn and/or stored meat for winter consumption, their diets may have contained less (or more) mammoth than these models suggest. These examples demonstrate that there is a widespread and as yet unrecognized need to consider edible tissue turnover rates, seasonal variations in animal diets, seasonal meat procurement, and food storage in human paleodiet reconstructions.

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Amino acid $\delta^{13}\text{C}$ analysis quantifies environmental change in a nearshore ecosystem through the Late Holocene

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Kelp forests are some of the most biodiverse and ubiquitous temperate marine ecosystems. These nearshore habitats are also highly sensitive to human impacts and among the most threatened marine ecosystems on earth. For conservation efforts to be effective, it is crucial we develop a thorough understanding of the spatial and temporal dynamics of kelp forests. Here, we employ $\delta^{13}\text{C}$ analysis of individual essential amino acids (AA_{ESS}) from ancient top consumers to evaluate the dynamics of southern California kelp forests across a period of rapid cultural change and accelerating human impacts (~3500 ybp to present). Because consumers typically directly route AA_{ESS} into their tissues these molecules are minimally altered through food chains. Moreover, different producers in nearshore marine ecosystems have highly distinct physiologies, causing patterns in their AA_{ESS} $\delta^{13}\text{C}$ to act as unique fingerprints that can be identified in consumers. We analyzed bone collagen extracted from sea otters (*Enhydra lutris*, $n = 29$) and sheephead (*Semicossyphus pulcher*, $n = 15$) sourced from late Holocene archaeological sites on two islands off southern California. We also characterized the AA_{ESS} $\delta^{13}\text{C}$ profiles for modern producer groups as baseline values for comparison: kelps (*Macrocystis* sp.), green algae (*Ulva* sp.), red algae (*Neorhodomela* sp. and *Endocladia* sp.), and offshore particulate organic matter. We used linear discriminant analysis (LDA) and Bayesian isotope mixing models (MixSIAR) to test the ability of AA_{ESS} $\delta^{13}\text{C}$ to distinguish between producer groups and to classify consumers according to their reliance on different producers. Results clearly showed the utility of the AA_{ESS} $\delta^{13}\text{C}$ approach in reconstructing ancient coastal environments. Kelps had significantly higher AA_{ESS} $\delta^{13}\text{C}$ values than other producers. Mixing models show that over 65% of ancient sea otter and sheephead AA_{ESS} were derived from kelp, indicating that these consumers were predominantly feeding in ecosystems driven by kelp production. In combination with bulk tissue analysis and ongoing AA_{ESS} $\delta^{13}\text{C}$ analysis of modern samples, these findings suggest that at these sites kelp forests were more extensive in the late Holocene than they are today. Our study demonstrates the application of amino acid $\delta^{13}\text{C}$ analysis in integrating historical ecological information and modern conservation biology.

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From Tarapacá to Stonehenge – The Challenge of Mummies and Cremated Bones

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From the arid desert of Atacama to the green plains of England, human remains have been buried and preserved in many ways. In Tarapacá, burial took place in extremely dry areas, leading to natural mummification preserving hair, skin, muscles, nails, bones and teeth of the people buried there. Those buried at the British site of Stonehenge, however, were almost exclusively cremated, leaving only white calcined fragmented remains. These differences in funerary practices and environmental conditions lead to different states of diagenesis and forces researchers to devise different investigation strategies to reconstruct the lives of those individuals. Still, isotope analysis can provide relevant evidence on the life histories of individuals from Tarapacá to Stonehenge. In the Atacama Desert, even though preservation appears to be excellent, there are a series of factors that affect the isotopic composition such as the aridity effect, use of fertilisers, complex marine ecological systems and geology, lack of precipitations and abundance of groundwater and springs making the interpretation of the results rather difficult. Still, the Atacama is a great place for the study of different types of human remains. At Stonehenge, however, due to the high temperature reached during cremation, all organic matter is destroyed, and only small calcined bone fragments remain, from which as much information has to be extracted. While carbon and nitrogen isotope analyses for palaeodietary studies are not possible, strontium isotope ratios can still be measured for palaeomobility investigations. In this paper we discuss different case studies where different methods needed to be used to study palaeodiet, palaeoecology and palaeomobility of ancient populations. These include Stonehenge (UK), the Ebro Valley (Spain), Pica and Tarapacá (Chile). Our comparison shows how bioarchaeological research can provide information on diet, mobility and/or funerary practices using different isotope ratios (e.g. $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, $\delta^{18}\text{O}$ and $^{87}\text{Sr}/^{86}\text{Sr}$) measured on different tissues (bone collagen, bone apatite, hair, dentine, tooth enamel, etc.) from a wide range of contexts (arid, wet, coastal, etc.). This allows for a better global understanding of important cultural processes during prehistory such as the transition to agriculture, the emergence of complex societies as well as migrations.

DH387GF

Archaeology and Palaeoecology I

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Deciphering millennial-scale Antarctic ecosystem change using amino acid stable isotope analysis of modern and ancient penguin eggshell

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The Southern Ocean ecosystem is undergoing rapid environmental change due to ongoing and historic anthropogenic impacts such as climate change and marine mammal harvesting. These disturbances may have cascading effects through Antarctic food webs, manifested as behavioral responses in higher-trophic organisms, such as penguins. For example, bulk stable isotope analyses suggest variations in Adélie penguin (*Pygoscelis adeliae*) feeding ecology throughout the Holocene, with dramatic isotopic shifts sometime within the last ~200 years. However, it is not clear whether these isotopic shifts resulted from changes in isotope values at the base of the food web, trophic shifts in penguins, or some combination of both factors. Compound-specific stable nitrogen isotope analysis of amino acids (CSIA-AA) provides a powerful new tool to tease apart these confounding variables. Stable nitrogen isotope values of trophic amino acids (e.g., glutamic acid) increase substantially with each trophic transfer in the food web, while values of source amino acids (e.g., phenylalanine) remain relatively unchanged and reflect ecosystem baselines. We applied the CSIA-AA approach to modern and ancient Adélie penguin eggshells in Antarctica to disentangle baseline and trophic shifts throughout the last 8,000 years. Modern eggshell had lower glutamic acid and phenylalanine $\delta^{15}\text{N}$ values relative to ancient samples. These results indicate that both shifts at the base of the food web as well as a decrease in trophic position in Adélie penguins occurred between ancient and modern samples. This sheds new light on previous analyses of bulk $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ analyses and suggests that Adélie penguins switched their diet from high trophic level fish to low trophic level krill sometime in the last 200 years. In addition, shifts in phenylalanine $\delta^{15}\text{N}$ values imply concurrent changes in baseline ecosystem conditions in Antarctica, something that could not be identified with bulk stable isotope analysis. This work applies a new molecular geochemistry approach to penguins as sensitive indicators of past environmental change in Antarctica and in combination with other paleo-climatic and -productivity proxies could help interpret drivers of Antarctic ecosystem change through the Holocene.

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Isotopic insight on the palaeobiology of late Pleistocene giant ground sloths in the southern Cone of South America

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Giant ground sloths were an important ecological component during the Late Pleistocene in South America, with numerous species ranging in size from that of a sheep to that of an elephant. Due to the lack of modern analogue and the simple structure of their teeth, their diet is difficult to reconstruct, and different hypotheses were proposed for several species, from pure herbivore to omnivore, scavenger, or even predatory carnivore. Many of them also interacted with the first human inhabitants of South America, so understanding how these extinct mammals fitted into their respective ecosystems is important. The collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values as well as the carbonate $\delta^{13}\text{C}$ values were measured for the bones of different ground sloth species (*Glossotherium* sp, *Megatherium americanum*, *Myiodon darwini*) as well as coeval herbivores (e.g. Glyptodontids, equids, camelids, *Macrauchenia*) and predatory carnivores (e.g. *Smilodon*, *Panthera onca mesembrina*). The material comes from sites in the Buenos Aires Province (Argentina) and the Cueva del Milodon in southern Chile. Collagen quality was checked through chemical composition (%C, %N, C/N) and carbonate preservation was verified through comparison of the difference in $\delta^{13}\text{C}$ between carbonate and collagen ($D\delta^{13}\text{C}_{\text{carb-coll}}$) with modern species of similar trophic ecology. The $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of most ground sloths are in the range of coeval herbivores, indicating a diet essentially composed of C3 plants with some C4 plants in the Buenos Aires Province. Some *Megatherium* specimens exhibited isotopic values close to those of predatory felids. However, since some pure herbivores, such as *Macrauchenia*, are in the same case, no palaeodietary inference can be made. In contrast, the $D\delta^{13}\text{C}_{\text{carb-coll}}$ clearly discriminates between herbivores and consumers of animal food (omnivores, insectivores, carnivores), and all the studied ground sloth, including *Megatherium*, are in the herbivore range of values. Once having checked the preservation of the carbon isotopic values of bone carbonate by using species with well-known diet, it is possible to use the $D\delta^{13}\text{C}_{\text{carb-coll}}$ as a tool to evaluate herbivory or carnivory of extinct species, especially when collagen isotopic values do not discriminate well between these two trophic categories.

DFG, Project # BO 3487/4-1: "Paleoecology and evolution of the carnivorous mammalian faunas of South America from the Late Miocene to the Pleistocene: insights from stable isotopic signatures (^{13}C , ^{15}N , ^{18}O) in fossil bones and teeth".

JM669GQ
Archaeology and Palaeoecology I
Oral presentation Thursday 2 August 2018

A rodent midden leaf-wax $\delta^2\text{H}$ record reveals shifting sources of tropical moisture over the last 1700 yrs. in the Andes of northernmost Chile

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Diverse paleoclimate records have been used to reconstruct the timing and duration of past moisture variations in northern Chile's Atacama Desert, which today receives tropical moisture from both the Amazon (NE component) and Gran Chaco (SE component) basins. Yet, little is understood as to how the underlying climate dynamics drive these changes, especially since these events were of greater magnitude than those typically witnessed in the historical record. To this end, we have extracted and analyzed a $\delta^2\text{H}$ -leaf wax record from 29 ancient rodent middens collected in the precordillera of northernmost Chile that date to the last 1700 years. Rodent middens are debris piles of rodent feces, bones, plant and other organic remains encased in crystallized urine which preserves and seals these deposits over many millennia. They are readily datable by radiocarbon and constitute discrete "snapshots" of the local ecosystems that must be collated into series from individual localities. $\delta^2\text{H}$ biomarker (C31) values range from -59.7 to -81.7 ‰ which confirm an Atlantic moisture source. Yet, very large and variable shifts of more than 20 ‰ occur in $\delta^2\text{H}$ biomarker values throughout the record. Comparisons to other paleoclimate records show that more positive (more negative) values mostly line up with wetter (drier) periods in the past, implying that shifting moisture sources over time rather than an amount effect is the likely explanation. Our record shows that periods of increased regional moisture were due to an intensification of the NE component, whereas tropical rainfall during periods of drought was exclusively sourced from the SE component. Understanding these dynamics is crucial to further improve our comprehension of the relative contributions of local vs. extralocal forcing in the past and for future greenhouse gas warming scenarios.

FONDECYT 1150763, PFB-23 (to IEB), Anillo SOC1405

KL574MN

Archaeology and Palaeoecology I

Oral presentation Thursday 2 August 2018

Nearshore paleoceanographic conditions and human adaptation on the coast of the Atacama Desert (Taltal, 25°S) during the Early and Middle Holocene. Oxygen isotope analyses ($\delta^{18}\text{O}$) on *Fissurella maxima* shells

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Fissurella maxima is a keyhole limpet that is abundant and well preserved in archaeological shell midden sites along the coast of Chile, making it an appropriate species to use for reconstructions of past sea surface temperature (SST). In the present study, we evaluate the potential of *F. maxima* shells as a proxy of SST analyzing $\delta^{18}\text{O}$ of modern shells collected alive from rocky shores and archaeological shells from Early and Middle Holocene sites on the Atacama Desert coast (Taltal, 25°S). Reconstructed SST from modern *F. maxima* shells were related to instrumental SST from in situ thermometers, supporting the use of this mollusk species as a paleotemperature archive. Changes in mean SST were observed through the first half of the Holocene (from ~12000 to 6000 cal before present). Compared with present-day mean SST, Early Holocene water temperature was cooler and Middle Holocene water was similar. Paleo-SST data from archaeological sites along the coast of Taltal (25°S), provide insight into what is known about nearshore paleoceanographic scenario during the Holocene along the Pacific coast of South America. Our results offer a methodological discussion on the use of *Fissurella* species as a SST proxy and contribute to a better understanding of the latitudinal distribution of the coastal upwelling regime during the Holocene along the northern coast of Chile. Our archaeological paleo-SST record extends southward the coastal upwelling conditions, reported for southern Peru and northern Chile (23°S) during the Early Holocene. Recorded changes in seawater temperature from cooler to warmer conditions were crucial for human adaptation to the coast. During the Early Holocene, there is evidence for the earliest human communities along the coast of South America and during the Early-Middle Holocene transition, these communities developed a consolidated fishing subsistence with a marked increase in fish remains and the specialized fishing tools. In this regard, archaeological data will be presented to discuss the relationship between nearshore paleoceanographic conditions and socio-cultural changes through Prehistory

FONDECYT #1151203, 1150210, 3170913, 1181300 and FONDAP/CONICYT 151100 (to CR2).

Tracking trophic shifts through time in a threatened parrot

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When ecosystems are diminishing or under severe pressure, trophic position can change in affected species. Resource competition may also lead to changes in intraspecific niche width, signalling that conservation action is required. In New Zealand, alpine and sub-alpine ecosystems have been extensively modified since 19th century European settlement, with consequences for species such as the kea (*Nestor notabilis*).

We examined potential dietary changes in kea from 1880s-2000s, analysing feathers for bulk carbon and nitrogen isotopes from 68 kea from museum collections. We recorded specimen accession details such as provenance and sex. We also measured cere length as an indicator of size. We predicted that early 20th century kea would have elevated trophic levels as many protein sources were available, particularly with the expansion of high country sheep farming during this period. We expected modern kea populations would be more herbivorous, in line with reduced lowland habitat and protein food sources.

Kea feathers from the 1920s had enriched ¹⁵N, more than threefold that of modern kea; isotopic data from the 2000s specimens suggest modern kea eat a predominantly vegetative diet. Niche width also apparently decreased through time, but we did not detect differences between males and females. We conducted further compound specific analyses on a subset of the data, to ensure this trophic shift was not the product of variant baselines. We discuss our findings in relation to observational feeding studies, and the relevance of trophic shifts to the current threatened status of this endemic parrot.

Centre for Sustainability, University of Otago and Royal Society of New Zealand

PLENARY FRIDAY 3 AUGUST 2018 09:00 - 10:00.

The isotopic complexity of complex organisms.

Tamsin O'Connell

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Isotopic values of consumer tissues have been used for several decades to investigate individuals' dietary intake across a range of fields, particularly ecology and archaeology. In this talk, I will argue that many users of light stable isotope analyses at natural abundance underestimate the complexity of the metabolic processes that lead to their observed data.

I will outline some of the issues that confront us as we try to unravel the tangled web that is isotopic patterning in consumer data. I hope to demonstrate why a better understanding of this complexity matters to all of us using this technique, and to suggest a different way of viewing the processes that lead to the emergence of the isotopic patterning that we observe.

NP958NT
Archaeology and Palaeoecology II
Oral presentation Friday 3 August 2018

Stable isotope analysis in the Atacama Desert (northern Chile): complexities and challenges for archaeological and Andean studies

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Stable isotope analysis (SIA) has proved a useful tool for studying different archaeological contexts around the world. The Atacama Desert (northern Chile) is not the exception, with an increasing number of studies using SIA. Due to its extreme arid conditions, preservation of archaeological materials and bioanthropological tissues is excellent. Seeds, grains, maize cobs, complete animals and their parts (i.e. camelids, dogs, fish), human hair, skin, nails, muscles and bones are just some examples of the remains or tissues preserved in the Atacama. However, interpretation of SIA results here are often not as straightforward as they seem, as a number of important factors need to be considered when evaluating isotope values. The aim of this work is to discuss the complexities and challenges of using stable isotope analysis in the Atacama Desert for archaeological studies dating from 1000 BC- AD 1450. We focus specifically on $\delta^{15}\text{N}$ values in wild and domestic plants, domestic animals and humans, which show an extremely high enrichment in ^{15}N , despite their relatively low putative trophic position. For instance, human $\delta^{15}\text{N}$ values from coastal sites can reach values close to 27‰. Factors such as the aridity effect, geographical location, the upwelling system in the Pacific Ocean and the use of fertilisers (artificially or naturally) are discussed in order to explain such high $\delta^{15}\text{N}$ values. These aspects are of great relevance in archaeological studies, since high $\delta^{15}\text{N}$ values in human remains are usually interpreted as the consumption of marine diet in different regions distant to the coast. However, this enrichment can also reflect the influence of the factors mentioned above. Understanding stable nitrogen isotopes in the Atacama Desert is essential for reliable archaeological (and ecological) research, avoiding possible misinterpretations and confusions when studying the past. At the same time, we propose it as a challenge considering all the many factors, ecological, geographical and anthropological that could be causing this enrichment in ^{15}N . This study highlights the need for multidisciplinary approach in such studies including archaeologists, anthropologists and ecologists.

Becas Chile CONICYT

PF886LQ

Archaeology and Palaeoecology II

Oral presentation Friday 3 August 2018

Past Camelid herding and ritual practices on the northern coast of Peru revealed by stable isotopic analysis

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Despite the recent renewal interest in the high quality of their wool fibers, the place of domestic camelids, llamas (*Lama glama*) and alpacas (*Vicugna pacos*), have a limited role in the economic and social life of modern Andean people. On the contrary, domestic camelids had a preponderant place during the pre-Hispanic period. In addition to supplying meat and wool, they were used as pack animals for trading between ecological zones and played an essential role in ritual life of pre-Hispanic populations. Today camelid breeding is mostly restricted to the high elevation ecozone (*puna*) while the numerous archaeological remains found in Peruvian lowlands sites suggest that it was not the case in the past. The development of stable isotope analysis (SIA) in northern and southern Peru has recently shown that the lowlands (coast and middle valleys) have indeed sheltered permanent herds. Within this general framework our study addresses the questions of herding and ritual practices on the northern coast of Peru during the Late Intermediate Period (AD 1000-1450). It relies on the analysis of a large number of remains from funerary and sacrificial contexts located in the Chicama and Moche Valleys. The quality of the preservation of organic and mineralized tissues is excellent due to coastal arid conditions. SIA of teeth and bones provide diachronic information on the diet and residential mobility of camelids. Our data shows the existence of local breeding and a large diversity in dietary resources. Animals fed on local natural resources and/or were foddered with C₃ and C₄ cultigens. Diversity in husbandry practices is discussed by comparison with previous isotopic datasets. Age and coat color could be assessed for most individuals. The crossing of biological and physical characteristics with isotopic data allows to getting insight into individual selection criteria made by officiants for ritual practices. Some practices that may precede Inka times can thus be documented despite the lack of ethnohistoric testimony. SIA offers a unique opportunity to document diversity in Andean pastoralism before the social and economic upheaval caused by the Spanish Conquest.

ANR CAMELANDES under Grant ANR-15-CE27-0002-01

PM776NK
Archaeology and Palaeoecology II
Oral presentation Friday 3 August 2018

Isotopic data on human mobility in prehispanic communities in Central Chile

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Horticultural societies in Central Chile underwent profound changes around the year AD 1000: Pottery morphology, its fabrics and decorations, lithic technology, funerary practices, body ornaments, smoking and/or inhaling objects, all show notable differences, together with an increase in maize consumption. Most cultural practices have material correlates that enable archaeologists to study these changes. Social organization and the way people move in their territories is more elusive. The purpose of this paper is to show how stable isotope analyses are contributing in comparing human mobility patterns between the Early (pre AD 1000 Bato and Llolleo Cultures) and the Late Intermediate Ceramic Periods (post AD 1000 Aconcagua Culture) to add a new dimension to understand these changes. In this presentation we will explore three isotopic lines of evidence: coastal vs inland resources consumption ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) and drinking water isotope composition ($\delta^{18}\text{O}$) to monitor movements along an East-West axis, and changes along personal life histories (C, N and O isotope composition of paired bone and teeth) to track if people lived in isotopically different regions as a child and as an adult. The results will be analyzed and discussed using the isotopic results for approximately 100 human individuals, 40 of them with paired bone and teeth samples, supported by data for plant and animal samples that establishes a local isotopic baseline and the oxygen isotope composition of meteoric water, both available for our study region. The results provide new insights on social relationships and show slight differences between the periods under study. The main contribution of these analyses has been to reveal decreased residential mobility during the Late Intermediate Period together with an increase in socio-spatial relationships among coastal and coastal valleys inhabitants.

Fondecyt 1160511

QK265DT

Archaeology and Palaeoecology

Oral presentation Friday 3 August 2018

Humans, climate, pinnipeds, and their isotopic relationships from the Holocene to the Anthropocene in Tierra del Fuego

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Marine food webs in coastal southern South America are thought to have been significantly impacted over time in response to humans and climate in the Holocene and Anthropocene. The relative influence of humans, climate and ecological interactions on marine food web structure and ecological dynamics is poorly known in this region. Archaeological sites on the south coast of Tierra del Fuego, Argentina, created by marine hunter-gatherers, provide an abundant and valuable biogeochemical record that can inform us about these ecological dynamics over time. This record appears in the form of bone collagen from Otariids, southern fur seals (*Arctocephalus australis*) and southern sea lions (*Otaria flavescens*), high trophic level marine predators. To help quantify ecological relationships between humans, climate and food webs, we measured bulk stable isotope ratios and compound specific stable isotope ratios in amino acids from bone collagen in archaeological and modern fur seals and sea lions. Highly variable within species bulk stable isotope ratios of carbon and nitrogen can be linked to potential dietary differences (greater than two trophic levels) or habitat specialization (kelp dominated coastal areas or phytoplankton based open ocean) in ancient populations (7000-300 cal. years BP). Compound specific amino acid isotope measurements of carbon, nitrogen and hydrogen suggest both dietary differences and habitat specialization exist in populations over this time. However, changes in bulk isotopic ratios that decrease over time in Otariids are likely due to human influence rather than climate variability, as essential ($\delta^{13}\text{C}$) and source ($\delta^{15}\text{N}$) amino acid isotopic compositions largely stay the same. In modern populations (20th century), bulk isotope ratios suggest more diverse diets and habitats that represent major shifts in marine food webs during the transition from subsistence hunting of Otariids to industrial hunting and expanded human influence in coastal Tierra del Fuego. Direct human influences such as hunting and habitat alteration have been the primary drivers of ecological change in southern South American marine ecosystems in both modern and archaeological time periods, from more than six thousand years to the present.

RL891JR

Area: Archaeology and Palaeoecology II

Oral presentation Friday 3 August 2018

The life and times of a mummified steppe bison (*Bison priscus*) from Arctic Alaska told through his isotopic and molecular chemistry.

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Northern Alaska is experiencing some of the most rapid climate change globally and is also at the center of questions surrounding the settlement of North America's earliest humans. Understanding how past animals in this region interacted with their environment is key for examining both these research areas. Paleoecology in the far north is benefited by a wealth of well-preserved faunal specimens. The combination of dry and cold climate, rapid sedimentation, and permafrost has led to the north serving as a long-term storage freezer of ancient organisms. Forensic analyses of faunal specimens, including isotopic and molecular techniques, can add to an understanding of an individual specimen's environment and their mobility. A mummified steppe bison from the Northern Alaska, affectionately known as 'Bison Bob', is providing a glimpse of what is possible using a multidisciplinary approach. Stable carbon and oxygen isotope analyses of carbonate sequentially sampled from growth layers of its teeth indicate a yearly cycle with fluctuations in climate and food availability. The interpretation of these paleo data is aided by isotopic analyses of modern wood bison, recently released into the Inoko Flats, Alaska. We are also including analyses of strontium isotope ratios ($Sr87/Sr86$), which can inform us about the mobility of bison; by comparing strontium isotope data from sequential growth layers in Bison Bob's tooth enamel to spatial strontium isotope models of Alaska. From these comparisons, it appears that Bison Bob began his life on the coastal plain of the North Slope and then moved south into the foothills of the Brooks Range during his second year of life. Molecular clock estimates derived from the mitochondrial genomes of Bison Bob and other bison indicate that this individual, who has a non-finite radiocarbon age, is likely to be between ~50-82 thousand years old. These mitochondrial data can also potentially provide insight into the metapopulation dynamics of bison in a discontinuous landscape. Multidisciplinary approaches combining light and heavy isotopes as well as ancient genetic information are in this case providing a greater understanding of how ancient bison interacted with its environment.

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TC791GF

Archaeology and Palaeoecology II

Oral presentation Friday 3 August 2018

Tracking 30 years of movement and feeding ecology of a 17,000 year old woolly mammoth (*Mammuthus primigenius*) from Arctic Alaska

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Arctic Alaska is experiencing tremendous changes as a result of recent warming and has also seen dramatic environmental changes since the last glacial maximum (LGM, 21,000 years ago). During the LGM this region was inhabited by a wide range of now extinct mega-fauna, including woolly mammoths (*Mammuthus primigenius*), the demise of which is still hotly debated. Although the life of mammoths has been portrayed as including large seasonal migrations this picture is largely untested and based on the behavior of extant elephantids as analogues rather than data. Using a novel methodology, we conducted multi-isotope analyses along an entire woolly mammoth tusk found in Arctic Alaska. The specimen is one of two tusks associated with a skull from a single individual that was found north of the Brooks Range and well above the Arctic Circle. Calibrated radiocarbon dates from both the skull and one of the tusks indicate that the mammoth died approximately 17,000 years ago, during the LGM. We developed a method that allowed us to longitudinally split the curved 1.5 meter-long tusk using a band saw. Based on histological evidence, the individual was determined to be greater than 30 years old at the time of death. We subsequently sampled sequentially along the entire length of the exposed inner surface of the tusk for stable isotope analyses (N,C on the organic fraction and C,O on the inorganic fraction) as well as strontium isotope ratios (Sr87/Sr86) in order to provide a reconstruction of the animal's feeding ecology, environment and movement over the course of its entire life time. For the first time, we interpret the life history, including diet, movement and environment, of a woolly mammoth from birth to death using this multi-isotope approach.

National Science Foundation and the University of Alaska Fairbanks

MS271PD

New methods and models in isotope ecology II

Oral presentation Friday 3 August 2018

How do behaviour, the environment and physiology interact to produce variance in tissue isotopic compositions?

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Variations in stable hydrogen and oxygen isotopic compositions of animal tissues are commonly used for location and movement reconstructions. The underlying premise is that the isotopic compositions of tissues reflect those of the local water or environment, overlain by a relatively predictable offset. However, substantial variance in hydrogen and oxygen isotope values is often observed among tissues grown at the same site, challenging the interpretation of isotopic data to infer movement. Process-based, mechanistic models incorporate the underlying mechanisms of isotopic variation, starting from first principles. These models allow sensitivity testing, and thus the identification of parameters with largest influences in tissue isotopic compositions, as well as the simulation of isotopic means and variances under a range of conditions. We developed a novel theoretical modelling approach to explore how behaviour, the environment and physiology interact to produce variance in tissue isotopic compositions. The model system is the bird community of the Red Butte Canyon, UT, over the breeding season. Our model toolbox couples an agent-based model of bird movement and behaviour within the canyon, an isoscape model of environmental isotopic variability, and a physiology-biochemistry model, and ultimately predicts the hydrogen and oxygen isotopic ratios of body water and keratin. The isoscape model is informed by newly collected isotopic data for water and organic material from plants and insects from the Red Butte Canyon. We identified the behavioural modes, environmental conditions and physiological parameters with greatest effects on tissue isotope values, and compared predicted isotopic means and variances against measured data for a suite of bird species expressing contrasting traits. Our model toolbox allows exploring the isotopic consequences of specified traits, as well as the recovery of observed isotopic means and variances for the bird community of the Red Butte Canyon. This toolbox has a great value as a planning tool to strategise efficient sampling designs and data collections, as well as for hypothesis generation on the variety of processes that could explain observed patterns.

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PC961KT

New methods and models in isotope ecology II

Oral presentation Friday 3 August 2018

Improvements in sensitivity in IRMS measurements

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An increase in the sensitivity of isotope ratio mass spectrometers is required to meet the demands of researchers for smaller sample sizes, higher resolution sampling, and increased precision. Many ecological applications would benefit from improved sensitivity, for example biological samples which have very high C:N ratios, archaeological collagen samples which have very small amounts of sulphur, trace gases of very low concentrations, tree ring samples where the temporal resolution is limited by sample size, or any compound specific measurements where some compounds are present in very small amounts. Following an analysis of the ion optics of the Sercon Nier-type electron impact ion source, we have made modifications which ensure the area of ionisation is matched with the area of beam extraction. We have thus improved the overall efficiency of the source and the improvements in sensitivity are significant. Here we describe the modifications which have been made and present data to demonstrate how this is advantageous to the isotope ecology community.

PM343KG

New methods and models in isotope ecology II

Oral presentation Friday 3 August 2018

An essential amino acid $\delta^{13}\text{C}$ library for tracing the importance of biofilms and biocrusts in aquatic and terrestrial ecosystems

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Aquatic biofilms and soil biocrusts are ecologically important microbial assemblages that transform recalcitrant organic and inorganic energy into bioavailable forms. For example, heterotrophic biofilms may be an important mechanism by which recalcitrant terrestrial organic matter (e.g. cellulose) is broken down and made available to freshwater aquatic consumers. Similarly, the exchange of nutrients between soil biocrusts and adjacent plants in aridland ecosystems likely constitutes a key symbiotic relationship for surviving in resource-limited environments. Most studies examining heterotrophic biofilms and soil biocrusts have emphasized the *elements* exchanged (C, N, or P) among organisms, but have overlooked the possible exchange of complex molecules like amino acids. Well-defined patterns in essential amino acid (AA_{ESS}) $\delta^{13}\text{C}$ values (AA_{ESS} $\delta^{13}\text{C}$ fingerprints) of autotrophs (plants and protists) and heterotrophs (bacteria and fungi) that can synthesize AA_{ESS} *de novo* may provide enhanced discriminatory power to trace the flow of heterotrophic biofilm- and soil biocrust-derived energy through freshwater aquatic and terrestrial food webs. However, no study has generated a library of producer AA_{ESS} $\delta^{13}\text{C}$ fingerprints in either freshwater aquatic or terrestrial ecosystems at the landscape scale needed to address these hypotheses. We analyzed AA_{ESS} $\delta^{13}\text{C}$ values of 10 producer taxa, including instream algae and riparian trees from the Rio Grande River and C_3 forbs/shrubs, C_4 grasses, and CAM plants from the northern Chihuahuan Desert in New Mexico, USA ($n = 70$). Using a linear discriminant analysis (LDA), we characterized the AA_{ESS} $\delta^{13}\text{C}$ fingerprints of our producer taxa. The LDA returned a successful reclassification rate of $>70\%$ among our taxa. We can distinguish among C_3 photosynthetic plants at the genus level using AA_{ESS} $\delta^{13}\text{C}$ fingerprints, which cannot be done using bulk tissue $\delta^{13}\text{C}$ values. This library of freshwater aquatic and terrestrial producer AA_{ESS} $\delta^{13}\text{C}$ fingerprints will be invaluable for ongoing local studies of the roles heterotrophic biofilms and soil biocrusts play in aridland rivers and adjacent desert ecosystems. More broadly, this study highlights the potential for AA_{ESS} $\delta^{13}\text{C}$ analysis to reveal important biological interactions among producers, decomposers, and consumers in aquatic and terrestrial ecosystems.

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PP234RC

New methods and models in isotope ecology

Oral presentation Friday 3 August 2018

Are my isotopic inferences distorted? Quantification of the isotopic anamorphosis at intra- and inter-species levels.

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Inferring properties from stable isotope analysis to decipher trophic relationships depends on two strong assumptions: i) a constant and known trophic enrichment factor (TEF) and ii) isotopic steady state - the rate at which steady state is reached being dependent on the tissues isotopic turnover (measured by λ , the instantaneous incorporation constant). These two aspects of isotope dynamics have been questioned for 20 years and are now challenged using both theoretical *in silico* modelling and experimental approaches. The consequence of violating these assumptions is a distorted representation of the inferences derived from isotopic analyses, e.g. in reconstructing species diet, trophic niche and food web. We refer to these distortions as isotopic anamorphosis (like in a distorting mirror). We present evidence of the interconnectedness of TEF and λ . They both are functions of bioenergetics, scale with body mass, and vary with food availability, food quality and temperature. We hypothesize that integrating their process-based variations and their connection will improve inferences from isotope measurements. Most popular time models classically used to interpret diet switch experiments (DSE) are phenomenological and appear inappropriate to tackle these problems, as they do not recognize the interdependence and variability of TEF and λ . Mechanistic models recently developed such as the Dynamic Isotopic Budget (DIB) model provides a promising sound alternative. DIB is based on Dynamic Energy Budget theory which predicts many types of intra- and interspecific scaling relationships. DIB offers a sound theoretical basis and benefits from a collection of DEB parameters for over 1000 species. The drawback of DIB is that it is in its present form too complex for ecological applications. Here, we develop simpler dynamic incorporation rates that explicitly link TEF and λ , make predictions and examined whether these predictions are consistent with the more mechanistic DIB models. Our aim is to quantify isotopic anamorphosis in a wide range of animal species using both types of models. We will revisit DSE to characterize the link between TEF and λ in invertebrates and vertebrates, and its uncertainty. Then, we will evaluate the consequences of incorporating dynamics on diet and trophic niche estimations.

QF351SF

New methods and models in isotope ecology II

Oral presentation Friday 3 August 2018

Introducing ArDB: the cutting-edge analytical results database and data visualisation software from Elementar

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ArDB, Analytical Results Database, is a completely new software product for the stable isotope community and beyond. ArDB has been created to extend the envelope of data analysis beyond simply data processing. Perhaps more so than any other analytical technique, stable isotope ratio mass spectrometry is about comparison. Comparisons of one stable isotope to another; comparisons of a sample to a standard, and comparison of unknown samples to known samples within a database. Until now, IRMS manufacturers have concentrated solely on software to generate results. With ArDB, we provide powerful new results management and analytical tools. For any environmental sample, there will be many associated parameters which place the analytical results into context. For example: latitude/longitude, depth, proximity to potential source of pollution, season, storage conditions, etc. These parameters are what are commonly known as "metadata", and ArDB allows your analytical results to be evaluated in the context of these metadata. ArDB makes it possible to recognize patterns in data, evaluate similarities between unknown and known samples, and visualize data on maps and charts (i.e. ArDB may be used as a Geographical Information System, GIS). With this metadata-handling functionality, ArDB can be used to plan, coordinate and manage your sampling strategies and maintain quality through to the final data analysis. ArDB also incorporates the capability to apply common statistical methods to datasets, such as Principle Component Analysis (PCA) and Linear Discriminant Analysis (LDA), as well as supporting integration with the statistical software package R. As a database is constructed, it becomes possible to compare unknown samples with known samples within the database and evaluate statistical similarities or difference, which in turn can be used to inform likely sources of an analytical signal and potential trace that signal to likely sources, in environmental and forensic contexts.

SL154BM

New methods and models in isotope ecology II

Oral presentation Friday 3 August 2018

Functional traits unravel temporal changes in fish biomass production on artificial reefs

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Since the last decade, artificial reefs (ARs) have been deployed worldwide to sustain fisheries management. Although the answer to the attraction-production issue remains elusive, recent lines of evidence have concluded that production is the most probable cause of increase in fish biomass. The deployment in the Bay of Marseille of the largest artificial reef system in the Mediterranean was a unique opportunity to investigate interannual changes in the functional structure of fish community using 6 years of monitoring fish biomass and a trophic trait-based approach. Our results exhibited contrasted patterns of change between 7 functional groups and demonstrated that considering all species as a whole is inappropriate to accurately assess AR-induced effects. Benthic sedentary species predominated on the AR (>75% of the total biomass) through massive production (up to ×68 for benthic piscivores). Mobile species tended to vary seasonally and were only weakly influenced by these structures. Zooplanktivores were predominantly affected by environmental parameters that acted at larger spatial or temporal scales. By computing novel isotopic functional indices to identify how these changes may have affected organic matter fluxes over time, we revealed a maturation of the fish community as well as the main importance of local organic matter sources in supporting fish biomass production. By investigating changes at a functional group-level, we demonstrated that production and attraction are two extreme cases between which a range of contrasted patterns exist. As they can modulate fish species responses, functional attributes, such as trophic traits inferred from stomach contents and isotopic ratios, habitat requirements and species distributional ranges, must not be overlooked when the impacts of artificial reefs on fishery are examined.

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TT488FT

New methods and models in isotope ecology II

Oral presentation Friday 3 August 2018

Advances in NCS analysis in EA-IRMS for Ecological Applications: Getting more for less with ultra-high sensitivity

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Recent advances in Elemental Analysis Isotope Ratio Mass Spectrometry (EA-IRMS) provide an opportunity to advance ecological studies on carbon, nitrogen and sulfur biogeochemical cycling, and to better constrain ecological processes in space and time. This presentation will explore ecological data acquired on an ultra-sensitive EA-IRMS system, which will demonstrate a significant advance in the analysis of small sample concentrations (< 5µg of nitrogen, carbon and sulphur), sample throughput and cost per analysis. The innovative features open doors to push research boundaries to new levels, especially with respect to simultaneous nitrogen, carbon and sulphur analysis and on very high C/N and C/S ratio samples. For example, complete baseline separation is shown with sound background correction and sharp peak shapes for very large (7000 µg C) and very small (11 µg N and 0.8 µg S) analyte amounts. For 5 replicate measurements on wood, $\delta^{13}\text{C} = -24.10 \pm 0.06\text{‰}$; $\delta^{15}\text{N} = 3.20 \pm 0.23\text{‰}$ and $\delta^{34}\text{S} = 5.92 \pm 0.26\text{‰}$. Further, this presentation explores the analysis of small concentrations of carbon, nitrogen and sulphur and illustrate, with real sample data, how the EA-IRMS utilises chromatographic principles to routinely increase the sensitivity on NCS measurements without the requirement of technical modifications. In one example, analysis of bone collagen will be shown where simultaneous NCS analysis is obtained on 1 mg of analysed bone collagen, with gains in sulphur sensitivity demonstrated of the order of a factor of 10, and higher. The implications of this work allow for the analysis of significantly smaller sample amounts, reducing combustion complications, longer reactor lifetime and access to sample information hitherto inaccessible. In addition, it provides for the production of accurate and highly precise data for nitrogen, carbon and sulphur, with precisions achievable of $\leq 0.3\text{‰}$ for < 5µg sample concentrations.

KC958RR

Isotope ecology from individuals to communities III

Oral presentation Friday 3 August 2018

Structure, function and pelagic-benthic coupling in the Norwegian Arctic marine ecosystem

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The Barents Sea winter sea ice extent has been in decline since the late 1970s, and the Barents Sea overall shows anomalously warm ocean temperatures. Knowing the structure and function of the marine ecosystems in the Arctic is very important in order to manage responses to change. We took a large-scale approach to ecosystem analysis by analyzing bulk carbon and nitrogen stable isotope compositions of all key species, by mass or topology, representing the major pelagic, benthic-pelagic, and benthic components of the marine ecosystem in Norwegian Arctic. These whole community samples were taken throughout the Barents Sea from close to the Norwegian mainland (72° N) to north of Svalbard (81° N), and spanned a longitudinal range of 5° to 34° W, with fish samples covering a broader area from 70° to 81° N, 10° to 43° W. We find strong decoupling in $\delta^{13}\text{C}$ values between pelagic and benthic organisms, indicating weak pelagic-benthic coupling (P-B), which is consistent from the southernmost to northernmost stations, contrary to previous work linking the strength of P-B coupling to variations in winter sea ice cover. While $\delta^{13}\text{C}$ values varied largely with pelagic or benthic resource use, $\delta^{15}\text{N}$ values are strongly linked to trophic position and behaviour. These clear isotopic trends allow the ecosystem to be categorized by simple functional groups driven by depth zone and trophic behaviour that would otherwise be invisible. The linear isotopic increase in both ^{15}N and ^{13}C content from pelagic to benthic-pelagic, and the steeper linear increase (greater in $\delta^{15}\text{N}$ than $\delta^{13}\text{C}$ values) through the trophic levels of the benthic community provide references for comparison of depth and trophic behaviour. We can therefore determine behavioural and functional ecology from individual, to species, to community, to ecosystem level.

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PR859RC

Isotope ecology from individuals to communities III

Oral presentation Friday 3 August 2018

Inter- and intraspecific variability in isotopic niche widths of Southern Ocean pteropods

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Rising anthropogenic CO₂ is causing multi-stressor, climatic impacts on marine ecosystems. Among these impacts is ocean acidification, a process driving dissolution of calcareous shells of many marine organisms. Calcareous-shelled pteropods, or thecosomes, are small, free-floating marine snails that are highly sensitive to ocean acidification and thus considered first responders to climate change. Many studies demonstrate dissolution of shells at lower pH, however little research focuses on their role in marine ecosystems. While pteropods are ecologically important grazers on phytoplankton, and a food source for many higher trophic species, a basic understanding of their trophic structuring is still lacking. We conducted stable isotopes analysis to investigate the trophic relationships, including niche partitioning, of one thecosomatous (*Clio pyramidata* f. *sulcata*) and two shell-less gymnosomatous (*Clione limacina antarctica* and *Spongiobranchea australis*) pteropods that co-occurred between the southern extent of the Kerguelen Plateau and the Antarctic continent. For each species, we aimed to understand (1) how isotopic niche widths varied; and (2) whether there was a relationship between body length and trophic position. Thecosomes are generally considered herbivorous, while gymnosomes are carnivorous, with each species selectively feeding on different thecosomatous species. Hence, we expected high variability in niche partitioning between species, with gymnosome species exhibiting relatively narrower widths due to specialist diets, and *C. pyramidata* f. *sulcata* measuring a broader niche width pointing to primary consumer behaviour. We observed a high degree of niche overlap, and variable inter- and intraspecific isotopic niche widths for all species, with a niche width for *C. limacina antarctica* reflective of a more generalist diet than expected. Variability in trophic behaviour was also manifested through body size, where trophic position increased for *S. australis* and decreased for *C. limacina antarctica*, with increasing body length. We found no indication of a dietary shift towards carnivory with increased body size for *C. pyramidata* f. *sulcata*. Trophic positions ranged from 2.7 to 3.4, demonstrating that co-occurring pteropod assemblages within this ecosystem represent primary and secondary consumers. Combined, our results demonstrate variable trophic behaviours among co-occurring pteropod species that will provide valuable insights into community-level responses to anthropogenically-driven changes to food availability.

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QF773SB

Isotope ecology from individuals to communities III

Oral presentation Friday 3 August 2018

The effects of C₃ versus C₄ plant biomass on a granivorous small mammal community in the Chihuahuan Desert

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Arid ecosystems are regulated primarily from the bottom-up and are subject to highly stochastic variation in seasonal rainfall and productivity, which makes them excellent systems to assess how abiotic factors influence consumer community dynamics that are intimately tied to forage quantity and quality. In the northern Chihuahuan Desert, net primary productivity (NPP) of high quality C₃ and low quality C₄ plant resources fluctuates considerably on both intra- and inter-annual timescales, providing a useful system for examining the effects of resource quantity and quality on the diet and population status of desert consumers. Here, we combined a long-term (1999-2014) NPP dataset with estimates of small mammal abundance and diet via stable isotope analysis to examine the effects of C₃ and C₄ plant biomass on the population status of four closely-related granivorous rodents (family Heteromyidae) that coexist in two adjacent biomes: creosote shrubland and black grama grassland. We hypothesized that C₃ plant (shrub and forb) biomass would have the biggest impact on rodent abundance in both biomes. In the creosote shrubland, C₃ biomass was positively correlated with population size in 3 of 4 Heteromyid species, while C₄ biomass had no effect (perennial grasses) or was negatively correlated (annual shrubs) with population size in all rodents. In the black grama grassland, however, there were fewer significant correlations between C₃ or C₄ plant biomass and rodent population size, with one interesting exception. The populations of the two most similar-sized (~45-55g) species, *Dipodomys ordii* and *Dipodomys merriami*, that experience the largest degree of resource competition based on overlap in their isotopic niches, responded in opposite directions to C₄ resource availability in this biome. Lastly, using a subset of data in which we had isotope-based estimates of diets and direct measures of body condition, we found that *Dipodomys spectabilis* (~120g) had significantly higher fat reserves when their diets consisted primarily of C₃ plants compared to individuals that relied on C₄ grasses. These patterns provide an invaluable framework for predicting how this community will change under future climate conditions, which will likely decrease the overall amount of high quality C₃ biomass on the landscape.

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QH421PR

Isotope ecology from individuals to communities III

Oral presentation Friday 3 August 2018

Intra and interspecific trophic niche overlap between South American fur seals and sea lions in Uruguay

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High trophic overlap may lead to intraspecific or interspecific competition and segregation which in turn may affect population trends or cause dietary changes. In Pinnipeds, morphological, physiological, behavioral, and energetic requirements are different at each developmental stage and they may have differential sensitivity to environmental changes, in this way high intraspecific competition may occur. Furthermore, anthropogenic and natural variations in marine ecosystem may differentially affect the feeding responses of distinct age-classes. In Uruguay, two pinniped species breed sympatrically: the South American fur seal *Arctocephalus australis*, with a growing population, and the South American sea lion, *Otaria flavescens*, which is declining. Given the contrasting population growth trends of these species, we explored how the trophic patterns varied across age-classes over seven decades using annual growth layers of dentin collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values. Teeth from 50 *A. australis* and 37 *O. flavescens* were analyzed using SIBER. Age-classes of both species were segregated along time, with consistently higher $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values in *O. flavescens* and high isotopic niche overlap among age-classes within each species. Interspecific age-classes only overlapped during the 2000s when adult *A. australis* invaded juvenile and young adult *O. flavescens* niche area. This reveals the consumption of prey with similar isotopic values and potential inter-specific competition for trophic resources, which may have negatively affected *O. flavescens* demography by reducing juvenile recruitment, as individuals from younger age-classes are often weaker competitors. In the 2000 decade, the isotopic niches also tended to increase for all age-classes, reflecting that both pinniped species consumed a more generalist diet. A combination of factors may have generated greater stress for *O. flavescens* in the coastal area while *A. australis* was able to use offshore resources and feed at a greater variety of trophic levels.

This study was funded by the National Geographic Society Committee for Research and Exploration (Grant #8978-11).

RD181SP

Isotope ecology from individuals to communities III

Oral presentation Friday 3 August 2018

Feeding habits and bioenergetics insights of jack mackerels (*Trachurus murphyi*) in south eastern Pacific waters

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The catabolism of food is organized within the fish to harness chemical energy and substrates for use in anabolic and other life-sustaining processes. In fishes, the physiological mechanisms which achieve this are very complex, allowing the catabolism of a large variety of food molecules using the finite numbers of enzyme systems which are found in fish tissues. This work used a combination of stable isotopes, stomach contents and total energy to study the balance among dietary energy intake and the rate of feeding consumption of the jack mackerels in south eastern Pacific waters. The jack mackerel *Trachurus murphyi* is a highly migratory carangidae distributed in southern hemisphere of the Pacific Ocean. Although this species represents a high commercial value to fisheries, their trophic ecology is poorly understood. Stable isotopes (mixing models), stomach contents (PSIRI) and total energy (calories per gram) were performed to determine the diet and the consumption rate of specimens of mackerels. Also, the work used preys (eg: euphausiids, fish larvae) with low digestion stages and phytoplankton values as values *a priori* in mixing models. According to the mixing models, euphausiids were the most important preys of these mackerels ($90.4\% \pm 0.02$), which was according with the stomach contents (97.5% PSIRI). The gastric evacuation rate was 0.44 g h^{-1} and the rate of food consumption was 7.33 gr per day. The total energy models indicate that mackerels need to consume approximate the 0.3% of their body weight daily to maintain their mass production. The available data on consumption rates for mackerel species indicate high rates compared to those of shallower waters (2-5% of body weight). The results of our study indicate that the jack mackerel is an active predator with a high consumption rate in pelagic ecosystems of the Pacific Ocean. Also, our results reflect that *T. murphyi* is a meso-predator with active feeding behavior and a homogeneous diet with a clear influence of the phytoplankton from the pelagic ecosystems of the Pacific Ocean, which also is important for the evaluation and management of its fisheries.

IFOP-SUBPESCA 1049-36-LE16: Determinación de los ítems alimentarios y calidad de huevos de jurel durante el periodo de máxima actividad reproductiva en el sector oceánico de la zona centro-sur de Chile, año 2016

RF458BD

Isotope ecology from individuals to communities III

Oral presentation Friday 3 August 2018

Combined stomach content and stable isotope analyses suggests that marked dietary overlap between invasive and non-invasive species may be mediated through habitat segregation

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Although associated with considerable economic and ecological damage, the spread of invasive species allows ecologists to test fundamental ecological theory. Stable isotope analysis (SIA) has shown particular utility in the study of invasion ecology as it allows the rapid assessment of trophic relationships between native and non-native species. Ecological theory suggests that inferior competitors should increase their dietary niche width as competition strengthens. Starting in 2009, invasive gobies from the Ponto-Caspian area underwent a population explosion in the River Rhine, to the point where their abundances regularly exceed 70% of native fishes. Previous extensive analyses of stomach contents (SCA) revealed a large diet overlap between native and invasive fishes, and invasive gobies were shown to be superior in direct competition on limiting food resources. To analyze the width of the realized feeding niche, we used SIA of native and invasive fishes and their major food sources from the River Rhine. Native and invasive fishes had distinct isotopic niches in terms of $\delta^{15}\text{N}$ - $\delta^{13}\text{C}$ centroid location, although stomach contents analyses showed trophic overlap.

This indicates that they may have fed on similar prey, but that were inhabiting isotopically-distinct riverine habitats. Bayesian estimate of Standard Ellipse Area (SEA) revealed significantly larger dietary niche widths for the native asp (*Aspius aspius*), European perch (*Perca fluviatilis*) and pikeperch (*Sander lucioperca*) compared to their invasive counterparts round goby (*Neogobius melanostomus*), monkey goby (*N. fluviatilis*) and bighead goby (*Ponticola kessleri*). For the two latter species, documented ontogenetic changes in the use of food resources may be assumed to further decrease species-specific SEA. This is further evidenced by an apparent shift in the $\delta^{15}\text{N}$ - $\delta^{13}\text{C}$ isotope space occupied by the fish community over the long (muscle) and short (liver) term.

Our results highlight the value of SIA in invasion biology. Although SCA indicated trophic overlap, use of SIA suggested that the invasive and native fishes were partitioning resources, particularly over the long-term (muscle tissues) but that over shorter time periods, isotopic differences became less obvious. This capacity to separate the trophic niche by ecological function rather than taxonomy is of particular use where putative prey inhabit multiple habitats.

Ministry of Environment in North-Rhine-Westphalia; Millennium Nucleus INVASAL

RS269RQ

Isotope ecology from individuals to communities III

Oral presentation Friday 3 August 2018

Impact of recycled water on the trophic interactions among top consumers in a semi-arid region

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Climate and human water-use is increasing aridity on Earth, which may exacerbate the impacts of effluents from wastewater-treatment plants in rivers. Alterations in the structure of food-webs are among the most visible pollution effects in rivers, yet the effects on top consumers in semi-arid regions have not been unexplored in detail. Here we used stomach content and stable isotopes of carbon and nitrogen analyses to compare before and after the input from a wastewater treatment plant the trophic interactions among *Barbus meridionalis* and *Squalius laietanus* from Cyprinidae, the most common fish family in European waters. We also explored seasonal changes in the trophic interactions among the fish to test whether low flow conditions intensify the impacts of pollution on the food-web architecture. Both fish species had a similar isotopic niche in reference and polluted sites, with pollution increasing nitrogen and decreasing carbon isotopic signatures in the two fish species. Changes in the trophic position of fish were supported by a shift in diet from invertebrates from all trophic guilds towards a one based on Gastropoda and Chironomids from the detritivore guild. Fish from summer and winter were carbon enriched compared to other seasons, suggesting a seasonal change in the niche width of the two fish species. Our findings suggest that major changes in the trophic interactions among freshwater fish exposed to sewage discharges, even though water quality variables were within the legal safe thresholds in compliance with the Water Framework Directive of the European countries. Therefore, the use of recycled water to restore the ecological status of rivers in semi-arid regions requires increasing the dilution ability of rivers and more investment on wastewater treatment.

University of Barcelona, Becas Chile (CONICYT) & CIBAS

SC272KF

Isotope ecology from individuals to communities III

Oral presentation Friday 3 August 2018

Food-web dynamics and isotopic niches within two deep-sea canyons and adjacent slope habitats

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Submarine canyons are dynamic environments, where complex morphology, intense currents, and variable nutrient conditions influence the quality and availability of food fluxing to the seafloor. However, few studies have examined the trophic pathways of deep-sea canyon communities relative to those on the adjacent slopes. In this study, we sampled fauna, sediments and water for stable isotope analysis (SIA) and utilized standard ellipse areas (SEA_C), and Bayesian standard ellipses (SEA_B) to examine food-web structure and trophic niches in Baltimore and Norfolk canyons and their adjacent slopes along the U.S. mid-Atlantic margin. Mixed-effect models were developed to identify which factors, including depth, seafloor terrain (e.g., slope, rugosity), feeding group, system (canyon or slope), and/or site (Baltimore or Norfolk) were driving the patterns in the isotope data. Results revealed that fish and invertebrate communities were composed of isotopically diverse feeding groups, encompassing at least 5 trophic levels, with phytoplankton-derived carbon providing the basal food resource. Canyon consumers were significantly depleted in ¹³C relative to consumers on the adjacent slopes. Niche widths (SEA_C, SEA_B) varied among feeding groups, with little overlap between paired groups found in canyons compared to slopes, possibly due to differences in food selection, feeding habits, and habitat association. Distinct isotopic niches quantified from canyon suspension feeders may be due to assimilation of an isotopically discrete food source, including fresh organic matter. In contrast, benthic feeders were enriched in ¹³C relative to suspension feeders, consistent with the consumption of older and more refractory organic material. Benthic feeders had diverse SIA data, potentially because they represent a mixture of feeding types, with food resources that include sediment, infauna, and epibenthos. The large spread in δ¹³C values across consumer groups indicate that the isotopic composition of particulate organic matter changes, which may be a function of location within these canyons and slope environments. Ongoing analyses will elucidate how seafloor terrain, habitat, and location along the margin influence the food-web structure in canyon and slope environments.

US Geological Survey Environments Program.

SM157HH

Isotope ecology from individuals to communities III

Oral presentation Friday 3 August 2018

Stable isotopes and stoichiometric analysis reveal ecosystem level impact of invasive raspberry species on Darwin warbler finch native *Scalesia* forest

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Insectivorous Darwins warbler finch (*Certhidea olivacea*) populations on the Galapagos have been decimated by exotic invasive species. Their native habitat, *Scalesia* forest, has been heavily invaded by *Rubus niveus* and hit by a parasitic fly species *Philornis downsi*. *Rubus* aboveground cover is almost impenetrable in unmanaged areas equating to over 10 t ha⁻¹ of additional plant biomass. Given this we studied the effects of the *Rubus* removal management on the warbler finch in three areas: long-term management (C12), short-term management (C15) and no management (NC). We posited that foodweb disturbance could explain contrasting finch reproductive responses to *Philornis* and El-Niño events. We tracked changes in the dietary resources, available and consumed by the finches across breeding seasons in 2015 and 2016, using traditional and stable isotope approaches. We analysed nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) in the birds blood and arthropods, as indicators of resource use change, and measured mass abundance and diversity of arthropods (the available finch diet). In particular, we were interested in whether (1) isotope blood signatures track dietary changes due to habitat degradation, (2) isotopes provide information on finch dietary choice in relation to availability and quality of the food, and (3) prey quality (arthropod) is influenced by habitat degradation. Finally, we analysed the bird's dietary components to reconstruct diets using the MixSIAR package. Our results suggest that the *Rubus* management affects the finches nutrient intake significantly. Isotope and stoichiometric signatures in the blood were significantly different across management areas suggesting disruption of food web structure and major habitat degradation. Despite clear differences in ecosystem primary productivity, arthropod mass abundance was not significantly different in the management areas. However, C:N ratio of the arthropods was significantly lower in the unmanaged areas "fatter lower protein content". The signature of the low-quality diet was preserved in the finch blood. The low-quality diet appeared to lead to a significant reduction in finch size, which was revealed by tarsus length measurements. Taken together, these results suggest the unmanaged areas are nitrogen limited which has physiological consequences on finch breeding success and has resulted in an adaptive shift towards smaller finch size.

ST933GS

Isotope ecology from individuals to communities III

Oral presentation Friday 3 August 2018

Enhancing the interpretation of bulk (C and N) isotope oscillations in whisker samples from Steller sea lions using compound specific nitrogen isotope analyses of amino acids

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Several studies have documented oscillating patterns in bulk $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values along the mystacial vibrissae (whiskers) of both seals and sea lions. It has been postulated that these predictable isotopic cycles result from seasonal changes in feeding ecology but there are multiple competing interpretations that could account for these bulk oscillations, including seasonal migration between different habitats, changes in baseline isotope values or seasonal changes of trophic position. To examine these interpretations further we analyzed the $\delta^{15}\text{N}$ values of the essential amino acids phenylalanine and glutamic acid in segments from 11 adult female Steller sea lion (SSL; *Eumetopias jubatus*) whiskers. Glutamic acid has been shown to exhibit a systematic increase in $\delta^{15}\text{N}$ values with increasing trophic position, while phenylalanine shows very little increase in $\delta^{15}\text{N}$ values during the trophic transfer. We first conducted bulk isotope analyses along the length of each whiskers to determine the pattern of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ oscillations. We then selected a pair of sub-samples, one at a peak in the $\delta^{15}\text{N}$ bulk values (reflecting winter foraging) and one from an adjacent trough (reflecting summer foraging). These small sub-samples were then prepared for compound specific nitrogen isotope analyses of amino acids following previously published protocols. However, due to the very small sample size and the relatively low concentration of N relative to C in these keratin samples, each sample was concentrated to a small volume. Then 1 to 1.5 micro liters of each paired set of samples (total 22 samples) was manually injected into a GC-IRMS. For 8 SSL there was sufficient signal from phenylalanine and glutamic acid from both the peak and trough samples to examine whether there was a change in trophic level between the winter and summer diets. We found that despite some differences in isotopic baseline between individuals there was no trophic level difference between peaks and troughs. Based on the current understanding of isotopic changes in these amino acids with metabolism, our data suggest that the seasonal oscillations in bulk $\delta^{15}\text{N}$ values from SSL whiskers cannot be accounted for in terms of shifts in trophic position.

JD938LT

Isotope ecology from individuals to communities III

Oral presentation Friday 3 August 2018

Estimating jellyfish trophic position using bulk and amino acid $\delta^{15}\text{N}$ reveal strong and repeated agreements between methods, but marked differences between jellyfish species and capture locations

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Much discussion exists regarding the perceived negative impacts of large jellyfish aggregations on coastal tourism, clogging of fishing nets and blocking of industrial intakes. Conversely, some scientists have highlighted the 'positive' role that jellyfish can play in the marine environment. Little is known about the basic ecology of jellyfish and there is a pressing need to address this gap in our understanding. One measure required to understand jellyfish ecological function is trophic position (TP) – the long-term average height in the food chain at which energy and nutrients are assimilated. This is commonly estimated for consumers using bulk $\delta^{15}\text{N}$, which is compared to an isotopic baseline (primary-producer or primary-consumer) accounting for diet-consumer trophic discrimination. One experimental estimate exists for jellyfish trophic discrimination factor (TDF) for $\Delta^{15}\text{N}$: it is very low (0.1‰) compared to that estimated for other aquatic consumers (e.g. 2.9‰ [McCutchan et al 2003] or 3.4‰ [Post 2002]). As such, it is difficult to know whether estimates of jellyfish TP based on bulk isotopes and using typical TDFs are reliable. Recent developments have shown the potential of amino-acid $\delta^{15}\text{N}$ values to estimate TP. Here we compare TP based on bulk and amino-acid $\delta^{15}\text{N}$ for 6 species of jellyfish captured from the NE Atlantic (*Aurelia aurita*, *Cyanea capillata* & *C. lamarcki*), Mediterranean (*Pelagia noctiluca* and *Velella velella*) and SE Pacific (*P. noctiluca*). We estimated amino-acid TP by comparing values for Glu and Phe, with TDFs of 7.6 and 4.9 ‰, and calculated bootstrapped median \pm 97.5 percentile TP values. Bulk TP was estimated using tRophicPosition, a Bayesian model that includes variation in both consumer and baseline $\delta^{15}\text{N}$, as well as the TDF. We calculated median \pm 97.5% credibility-intervals for bulk TP using two commonly used TDFs (2.9 \pm 0.3 and 3.4 \pm 1‰). Results showed that median jellyfish TP varied considerably both using bulk (range:1.93– 3.5) and amino-acid $\delta^{15}\text{N}$ (2.51–4.74). TP values based on a bulk TDF of 2.9‰ and an amino-acid TDF of 7.6‰ overlapped for all comparisons, indicating that these commonly used values may be representative for jellyfish, allowing these important consumers to be included in isotopic food web studies.

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POSTER ABSTRACTS

Poster Session 1 Monday 30 July 2018

Imperial diets? Using stable isotope analysis to explore the local impact of the Inka Empire in Antofagasta de la Sierra (Catamarca, Argentina)

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The analysis of food consumption patterns within an internally differentiated group that in turn, was under control of an expanding empire can shed useful insights into the form, structure, and extent of state power, and how it affected local domestic economies and the daily life of people. A series of models have been suggested to explain how the Inka conquest affected local economics in Argentina, and elsewhere. One model proposes that the Inka ruled indirectly, promoting local leaders, and their management of their own people. In this scenario, only those directly linked to the Inka administration would have been affected by the new situation. Alternatively, a model of more direct control would have impacted significantly on the daily lives of conquered people. In this latter model, the Inka state would have broken up previous power networks and production organization, replacing them with new forms of economic behavior. These impacts would have included the extraction of surplus products by the state, as well as changes in local domestic production. Likewise, the Inka organized a system of controlled extraction of resources across the Andes, but the impact of the empire on local economic structures varied depending on given conditions, such as geographical location. The aim of this work is to explore the influence and impact of the Inka Empire on Prehispanic Antofagasta de la Sierra, Catamarca highlands, Argentina, on the basis of an isotopes analysis of changes in food consumption patterns. This study will employ stable isotopes of carbon ($^{13}\text{C}/^{12}\text{C}$) and nitrogen ($^{15}\text{N}/^{14}\text{N}$) analysis on the organic fraction (collagen) and inorganic carbon (hydroxyapatite) within human bones ($n = 10$) from two archaeological sites, *Tumba Bajo del Coypar* and *Rescate Familia Reales*. All the samples have been previously analyzed by FTIR-ATR and all the samples show acceptable C/N ratios. We also present new isotopic data from Camelidae specimens (*Llama glama* and *Vicugna vicugna*) and cultivated plants from the area. Our first results show little difference between individuals. But the amount of *Zea mays* being consumed by humans in the analyzed sample is much higher at this time, than for earlier Prehispanic periods in the area.

Laboratorio de Isótopos Estables, Instituto de Geología. Universidad Nacional Autónoma de México. Agencia Nacional de Promoción Científica y Tecnológica - PICT 2016. Consejo Nacional de Investigaciones Científicas y Técnicas

seasonal and decadal-scale foraging habits of three Hawaiian seabirds: insights from stable isotope analysis

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We investigated how foraging habits differ among three ecologically distinct wide-ranging seabirds using amino acid $\delta^{15}\text{N}$ proxies for nutrient regime ($\delta^{15}\text{N}_{\text{Phe}}$) and trophic position ($\Delta\delta^{15}\text{N}_{\text{Glu-Phe}}$). Isotope chronologies were developed on seasonal and decadal timescales with data from feather grown during the nonbreeding season and data from collagen, which reflects foraging habits averaged over a year or more. We evaluated seasonal differences in the foraging habits of Newell's shearwater (*Puffinus newelli*) and Laysan albatross (*Phoebastria immutabilis*) and extended this seasonal analysis back 50 to 100 years, respectively. We also compared collagen data from these species to published records from two breeding colonies of the Hawaiian petrel (*Pterodroma sandwichensis*). The isotope proxies show inter-population and interspecific foraging segregation that has persisted for several decades among the three study species. Moreover, modern Newell's shearwater and Laysan albatross employ foraging strategies that differ between the breeding and molting periods and are distinct between species, regardless of the season. The nutrient regime at the base of the food chain for Newell's shearwaters during the nonbreeding season underwent a shift within the last 50 years, whereas nonbreeding season foraging habits of Laysan albatross apparently remained stable over the past century. Both of these species experienced significant trophic declines (probability ≥ 0.97) within the past 100 years, echoing a similar decline observed in the Hawaiian petrel. The trophic decline was heavily weighted toward the nonbreeding season in Newell's shearwater and exclusive to the breeding season in Laysan albatross. Because our study species are broadly distributed across the North Pacific Ocean, employ distinct feeding strategies and exhibit several other divergent morphological and behavioral traits, the identified trophic declines suggest a pervasive shift in food web architecture within the past century. Furthermore, identifying whether isotopic shifts occurred primarily during a specific phase of the annual cycle (i.e., the breeding or nonbreeding season) could allow us to better understand the causes of trophic declines and the potential ecological consequences for populations of each affected species.

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Archaeology and Palaeoecology

Poster presentation Monday 30 July 2018

Isotopic evidence from archaeological fish shows significant environmental change in past Great Lakes ecosystem

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Museum specimens are increasingly used in isotopic time series studies to generate historical baseline or 'benchmark' datasets that provide a reference point for assessing the nature and extent of recent anthropogenic impacts on environmental conditions. In response to ongoing deterioration of many of the world's aquatic ecosystems, studies assessing environmental change in lakes, rivers, and oceans through isotopic analyses of archived fish tissue (scales and muscle) are becoming more common. In many cases, however, specimens from historical collections will postdate the largest impacts from early industrial activities and therefore may reflect environmental conditions that have already been deeply altered. Incorporation of archaeological fish remains has the potential to add centuries or millennia of temporal perspective to historical ecological isotopic time series. A major factor limiting the potential of archaeological fish remains as a resource has been relatively small sample sizes. While fish remains can be extremely abundant at archaeological sites, species-level taxonomic identifications are often only possible for a fraction of archaeological fish specimens. Recent advances with peptide mass fingerprinting applications to fish bone collagen provide outstanding potential to resolve taxonomic identifications for large numbers of specimens and can therefore substantially increase sample sizes. This study combines archaeological, historical (n=537; scale and bone collagen) and published modern (n=454 scale collagen and muscle) $\delta^{15}\text{N}$ values from three upper trophic level pelagic species as a highly integrative proxy measure for long-term (A.D. 1200-2000) changes in Lake Ontario's N-cycle and foodweb structure. We used peptide mass fingerprinting to confirm uncertain taxonomic identification for archaeological bones. Results show that between A.D. 1200-1800 Lake Ontario's foodweb and N-cycle were highly stable. A significant, consistent shift to higher $\delta^{15}\text{N}$ values ($\sim+5.8\%$) across all taxa occurred over the last 200 years, indicating that N-cycle and nutrient dynamics were (and continue to be) deeply, and pervasively, impacted by human activities. After A.D. 1800, intra-specific $\delta^{15}\text{N}$ variation increased while the difference in average $\delta^{15}\text{N}$ value between taxa decreased, suggesting reduced trophic niche partitioning. We advocate for increased integration of archaeological materials into historical ecological isotopic baselines.

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Archaeology and Palaeoecology

Poster presentation Monday 30 July 2018

Into the tropical-extratropical rainfall systems interaction in the southern Atacama Desert since 17ka

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The southernmost part of the Atacama Desert (24-27°S; AD) lies in the transitional area between the tropical (summer) and extra-tropical (winter) rainfall systems providing a unique chance to trace their interactions in the past. Even though the source of the rainfall associated to the different wet phases recorded since 17ka has been largely discussed, $\delta^{18}\text{O}$ isotopic analysis were not applied to answer such issues even when both rainfall systems have different isotopic signature. Here we present the first results aiming to develop a calibration of plant cellulose oxygen isotopes as an indicator of rainfall oxygen isotopes along the southern AD to provide the basis for robust paleoclimatic interpretations of the fossil plant macro-remains cellulose isotopic record preserved in rodent middens. Thus, modern water from (winter 2016/winter 2016-2017) rainfall, ice, snow, rivers and salt lakes as well as plants (*Jarava frigida*) samples were collected at 32 sites at different altitude and latitude in the southern AD. Besides, a characterization of the synoptic conditions prevailing during rainy days was carried out to state the modern mechanisms delivering precipitation throughout the area during the sampling period. Winter and summer rain water isotopic values are clearly aligned along the meteoric line and could be easily distinguished based on their $\delta^{18}\text{O}$ composition of $-12(\pm 1.1)\text{‰}$ and $-6.5(\pm 2.5)\text{‰}$ respectively. This significant isotopic difference confirms that winter and summer rainfall have different origin, extratropical vs. tropical, respectively. Ice and snow samples presented similar or more depleted $\delta^{18}\text{O}$ values ($\sim -14,7\text{‰}$) than winter precipitation which reflect the same source but solid precipitation. Rivers and salt lakes presented enriched $\delta^{18}\text{O}$ values ($-1,6\text{‰}$) which deviates from the meteoric line due to the high evaporation rates in these Altiplano basins. Summer (winter) precipitation $\delta^{18}\text{O}$ composition shows a negative (positive) correlation with altitude which is consistent with the origin of precipitation. It is also probable that winter rain $\delta^{18}\text{O}$ presents a latitudinal effect related to the distal location of the AD but also the synoptic mechanisms that delivered the precipitation. Once the plants (*Jarava frigida*) samples are isotopically ($\delta^{18}\text{O}$) analyzed, we will be jointly analyzed to complete the modern water-plants isotopic relationships.

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Archaeology and Palaeoecology

Poster presentation Monday 30 July 2018

Paleodiets of late Quaternary humans and mammals inferred from nitrogen isotopic composition of individual amino acids in bone collagen

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Stable isotope analysis of the organic fraction preserved in archaeological bones and teeth enables a reconstruction of food habits of humans and animals in the past. Among others, reconstructions of human dietary behaviors are essential to understanding not only how they may have driven other organisms into extinction (e.g. mammoths and cave bears) but also to test hypotheses about their own extinction (e.g. Neanderthals in Europe). Amino acid-specific nitrogen isotope analysis on bone/tooth collagen has recently been proposed as a useful tool for detecting or quantifying aquatic food resources and for quantifying the fraction of plant protein in the diet in terrestrial environments. Case studies in the late Pleistocene with a broad spatio-temporal distribution have allowed the potential of this approach to be tested, even though the number of applications is still limited. The technique is based on observed characteristic isotopic shifts in each trophic step in food webs for individual amino acids: “Trophic amino acids” (e.g., glutamate, aspartate) yield information regarding animal trophic position, while “source amino acids” (e.g., phenylalanine, methionine) yield information regarding the sources of food (dietary nitrogen) within the food web. Bayesian mixing models allow the quantification of the contribution of different food resources. Several case studies using this technique will be presented: these include dietary reconstruction of Neanderthals (*Homo neanderthalensis*) and early anatomically modern humans (*Homo sapiens*), as well as extinct mammals including cave bears (*Ursus spelaeus*) in the late Pleistocene of Europe. Moreover, some Holocene human populations will provide examples with contribution of aquatic resources. In addition, future directions for the use of this approach in anthropology/archaeology/palaeontology will be discussed.

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Archaeology and Palaeoecology
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Impact of prehistoric human hunters on the foraging ecology of the Arctic fox

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The Arctic fox (*Vulpes lagopus*) is an opportunistic predator and scavenger, but in the Canadian Arctic preys predominantly on lemmings. In the winter and for foxes living near marine coasts or on islands, marine foods can be a significant source of food (primarily from scavenged polar bear kills), particularly during years when lemming abundance is low. This poster presents carbon and nitrogen isotope data from Arctic foxes sampled from archaeological sites in the central Canadian Arctic Archipelago, primarily dating between A.D. 500 and A.D. 1500. The early samples are associated with human populations (Dorset) that utilized a diversified subsistence strategy, with caribou and ringed seal being the most important taxa consumed. The later are associated with genetically and cultural distinct human populations (Thule) that extensively hunted bowhead whales, leaving large carcasses on the landscape, the remnants of which are often still visible today. This poster examines whether and to what extent the arrival of this new human population around A.D. 1200 altered the foraging ecology of Arctic foxes, specifically by providing increased access to marine carrion to be scavenged. The results demonstrate that prior to the arrival of the Thule Inuit, Arctic foxes consumed almost exclusively terrestrial prey. During the Thule occupation of the region, however, foxes consumed higher proportions of marine foods overall and there was a large increase in fox isotopic niche width, with some individuals consuming mostly marine foods. Despite the low population density of this hunter-gatherer group, they appear to have significantly impacted the behaviour of the Arctic fox. While it is speculative, if marine foods buffer against years of lean prey availability (tracking lemming cycles), the hyperabundance of marine-derived nutrients available to Arctic foxes may have created conditions that favoured growth in the local Arctic fox population.

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Archaeology and Palaeoecology

Poster presentation Monday 30 July 2018

The early Pleistocene environment in Java: A palaeoenvironmental reconstruction from stable isotope analyses of Sangiran fossil shells

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A carbon and oxygen stable isotope study was undertaken on shell samples from the Upper Kalibeng up to the lower Pucangan layers in Sangiran Early Man Site in Java, Indonesia. These layers have succession four bivalves assemblages indicating changing environmental conditions from sublittoral marine environment to marine regression to continental development. Shells representative of these assemblages are marine bivalve *Glycymeris sp.* and freshwater bivalve *Corbicula pullata* shells in four layers namely, Kalibeng, Limestone, Breccia and Pucangan, and additionally modern shells of *Lymnaea javanica*, a typical freshwater gastropod were taken for stable isotope analyses. The average of oxygen and carbon isotope data of freshwater are lower ($\delta^{18}\text{O} \sim 1.56\text{‰}$ / $\delta^{13}\text{C} \sim -3.25\text{‰}$) than of marine ($\delta^{18}\text{O} \sim 1.4\text{‰}$ / $\delta^{13}\text{C} \sim 2.18\text{‰}$). Shell $\delta^{18}\text{O}$ records show that late Pliocene to Early Quaternary climates was dry with occasional periods of increased precipitation. While $\delta^{13}\text{C}$ records indicate a consistent mean shell $\delta^{13}\text{C}$ values around -3.0‰ . Changes in shell $\delta^{13}\text{C}$ can be interpreted as a reflection of changing vegetation composition. This result is consistent with the palaeoenvironmental records that conform in the geological layers of Sangiran. The climatic conditions reflected by the acquired isotopic values of shells are matched by pollen and sediment proxy sources. Studies of Quaternary records of shell $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ are useful for reconstructing climatic conditions and complement the already existing palaeoenvironmental information in Sangiran.

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Archaeology and Palaeoecology

Poster presentation Monday 30 July 2018

Unravelling nutrient assimilation into the coral skeletal organic matrix has implications for historical interpretations

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The skeletal organic matrix (SOM) of scleractinian corals (the organic portion of the skeleton comprised of proteins, lipids, and polysaccharides) is significant for both biogeochemical and paleoceanographic research because it preserves elements over geologic timescales. The carbon and nitrogen bound inside the SOM reflect the nutrient sources of the coral-algal holobiont at the time of carbonate nucleation. However, due to the limited amount of SOM present in the skeleton (0.01-0.1% by weight), methods for extraction and analysis are hindered, resulting in the lack of analyzed data. This has created a gap in our understanding of this central physiological process and the roles of different nutrient sources in coral growth. The low nitrogen content of SOM, a limiting nutrient in coral ecosystems, has made it difficult to understand nitrogen fluxes during calcification. Here, we discuss results from research that aims to answer the question: What form of nitrogen is used in the skeletal secretion process of calcifying corals? First, we tested a new skeletal cleaning methodology that ensures no coral tissue contamination. This allowed us to conduct a long-term isotope tracer experiment where we exposed coral nubbins to labeled inorganic (nitrate + bicarbonate) and organic (urea + glucose) nitrogen and carbon sources to investigate incorporation into the skeleton. Experiments show successful enrichment of the coral SOM, with increasing delta values in both inorganic and organic treatments concomitant with time. This work has important implications for identifying the forms of nitrogen corals use for calcification, and if nitrogen assimilation changes with anthropogenic impacts to the nitrogen cycle. Implications extend to fossil and coral skeletons in the paleo record, which can only be interpreted correctly by knowing the source of the incorporated nitrogen. Future research includes conducting a feeding experiment with varied food and nutrient sources, and investigating isotopic signals in corals recovered from excavated archaeological lime kilns.

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Archaeology and Palaeoecology

Poster presentation Monday 30 July 2018

Gazelle hunting activities around Tor Hamar rock-shelter in Jordan viewed from carbon and oxygen isotopic compositions of tooth enamel

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The stable carbon and oxygen isotopic composition of gazelles unearthed from the rock-shelter site of Tor Hamar in southern Jordan was measured for reconstructing hunting activities by Paleolithic humans in this area. Tor Hamar is located in the Jebel Qalkha area and has archaeological deposits dated to the Upper Palaeolithic (38-30 ka) and Epipalaeolithic (24-14 ka) periods. The excavations at the site have yielded remains of prey animals as well as stone tools, from which we selected Gazelle tooth enamel fragments for isotope analysis on the carbonate fraction. The isotopic analysis on animal teeth from archaeological sites allows to estimate diet and habitats of game (open/closed, drier/wetter, etc.). The obtained results suggest that Paleolithic people hunted gazelles across a wide range of altitude in nearby mountains, indicating higher extent of mobility compared to those observed at other sites of the Southern Levant. In this presentation, we will further discuss methodological issues in translating dental isotopic data into hunting activities by humans (e.g., estimations of hunting areas, diversity of game habitats, etc.).

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Archaeology and Palaeoecology

Poster presentation Monday 30 July 2018

Trophic ecology of fur seals and sea lions from northern Patagonia and their food webs through time

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High trophic level predators can integrate the biogeochemical characteristics of their habitat through diet, thus serving as ecosystem indicators. Here, we used carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope analysis of bone collagen from ancient and modern South American fur seals (*Arctocephalus australis*) and sea lions (*Otaria flavescens*) as proxies of potential changes in a regional marine food web through time. Modern samples come from individuals stranded in northern Patagonia during the period 1990-2007, whereas ancient samples come from coastal archaeological sites from southern Buenos Aires (~7000 ^{14}C YBP) and northern Patagonia (3500–800 ^{14}C YBP). Bulk bone collagen isotope analysis shows that fur seals and sea lions displayed a steady resource partitioning through time with some overlap in $\delta^{13}\text{C}$ vs $\delta^{15}\text{N}$ space over the three periods under study. In agreement with previous work, fur seals had lower $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values in comparison with sea lions, indicating that fur seals largely forage on pelagic resources, whereas sea lions primarily consume benthic prey. Mean $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of fur seals remained stable over time. In contrast, sea lions had lower $\delta^{13}\text{C}$ values ~7000 years ago than in subsequent periods, suggesting a more pelagic diet. Despite this shift, sea lions showed little overlap with the isotopic niche of Middle Holocene fur seals. Nevertheless, potential temporal shifts in the isotopic baseline of pelagic and coastal (benthic) food webs prevent us from robustly assessing changes in pinniped resource and habitat use. Currently, $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ analysis of individual amino acids (AAs) are in progress, and we anticipate this approach will provide us with data on how baseline (essential AAs) $\delta^{13}\text{C}$ and (source AAs) $\delta^{15}\text{N}$ values have changed over time in this ecosystem. In addition, offsets between source and trophic amino acid $\delta^{15}\text{N}$ values will provide a measure of pinniped trophic level and potential changes in food chain length in response to the development of industrial whaling, sealing, and fishing activities in this region over the past three centuries.

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Archaeology and Palaeoecology
Poster presentation Monday 30 July 2018

$\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ herbivores variability in a longitudinal transect of southern Patagonia during the Holocene

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Climate-environmental variables influence the natural distribution of carbon and nitrogen stable isotopes. Continental Patagonia presents ecological diversity, conditioned in large part by variations in precipitation, which have a strong downward gradient in the west-east direction. Thus, this study aims to evaluate $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ variability in herbivores of Southern Patagonia during the Holocene from a transect of *ca.* 400 km between 47° and 49° south latitude, spanning from the Andes mountain to the Atlantic coast. We analyzed $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ of bone collagen from 103 specimens from the archaeological record. The transect is segmented in three areas. The Western section corresponds to the forest and the forest-steppe ecotone, with specimens of huemul (*Hippocamelus bisulcus*) and guanaco (*Lama guanicoe*). The second, Central area reflects samples from the steppe and, finally, the third, a coastal terrestrial ecosystem bordering the Argentine sea. Guanacos were sampled from the latter two areas. The guanacos from the coastal area had values (N = 8) of $\delta^{13}\text{C}$ -19.5 ‰ ± 0.3 ‰ and $\delta^{15}\text{N}$ 8.6 ‰ ± 1 ‰. The guanacos from the central area had a mean (N = 57) of $\delta^{13}\text{C}$ -19.3 ‰ ± 0.8 ‰ and $\delta^{15}\text{N}$ 6.3 ‰ ± 1.2 ‰. In the Western area guanacos showed values (N=18) of $\delta^{13}\text{C}$ -20.0 ‰ ± 0.9 ‰ and $\delta^{15}\text{N}$ 2.7 ‰ ± 2.1 ‰, while the huemul (N=20) of -20.9 ‰ ± 0.7 ‰ and 1.3 ‰ ± 1 ‰ respectively. In this way, an increase in herbivore $\delta^{15}\text{N}$ values can be seen from the Andes mountains to the Atlantic coast. It is proposed that these variations respond to climatic environmental variables that affect the natural distribution of stable isotopes. In conclusion, these $\delta^{15}\text{N}$ values allow herbivores from the three areas to be differentiated and represents an opportunity to discuss aspects of diet and/or mobility, for either hunter-gatherers or faunal species.

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Archaeology and Palaeoecology

Poster presentation Monday 30 July 2018

Variability in stable isotopes (^{13}C , ^{15}N) of camelid bone collagen: Implication for Holocene Human Paleoeecology

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Camelids, mostly guanacos (*Lama guanicoe*) are the more prominent big sized herbivorous in South America and one of the most significant resource in human diet during the pre industrial period. From an archaeological perspective, human diet reconstruction using stable isotopes on bone collagen are based mostly using average values of camelids stable isotopes. The present paper confirms the high variation in camelid bone collagen stable isotopes (C and N). Holocene North Patagonia camelids bone collagen data shows variation between -20‰ to -14‰ in $\delta^{13}\text{C}$ and between 3‰ and 12‰ in $\delta^{15}\text{N}$ (n= 75). Ecological difference between Monte and Patagonia deserts explain part of these variation. This mean that the macro regional average value on camelids ^{13}C and ^{15}N , including different eco-regions, could generate an inaccurate human isotopic diet reconstruction. A smaller spatial scale taking into account phytogeographic units is preferable in this kind of studies

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Archaeology and Palaeoecology

Poster presentation Monday 30 July 2018

Simultaneous nitrogen, carbon and sulfur isotope analysis on bone collagen: A dietary recorder

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Measurements of nitrogen and carbon isotopes in bone collagen have been investigated for decades and interpreted reliably as an indicator of human and animal diets because they primarily reflect the protein fraction of the consumer's diet. It may also be possible to use the isotopic composition from mammal bone collagen records to track movement and past climate changes as vegetation sources (and hence food sources) change with temperature and aridity. More recently, sulphur isotopes have also been employed in dietary studies. In addition, they can also be used to trace geographic origins because of their relationship to the underlying geology. Most research, however, has focused on carbon and nitrogen stable isotope ratios (hereafter $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$), with far fewer studies incorporating sulphur stable isotope ratios (hereafter $\delta^{34}\text{S}$). The analysis of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ has been relatively routine in ecological and archaeological research, with growing interest and understanding of $\delta^{34}\text{S}$. Sulphur concentrations in bone collagen are generally very low, in the region of <0.3%, in comparison to nitrogen and carbon concentrations. Consequently, this presented an analytical challenge for simultaneous $\delta^{13}\text{C}$, $\delta^{15}\text{N}$ and $\delta^{34}\text{S}$ analysis and usually resulted in the need to analyze one sample for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ and another, larger sample, for $\delta^{34}\text{S}$ analysis to obtain sufficient signals and data precision. Alongside difficulties in analyzing and handling SO_2 gas, this limited or deterred researchers from actively pursuing sulphur analysis. Here, we present an improved yet routine Elemental Analysis Isotope Ratio Mass Spectrometry method that permits the simultaneous analysis of $\delta^{13}\text{C}$, $\delta^{15}\text{N}$ and $\delta^{34}\text{S}$ on bone collagen samples with a total sample weight of 1 mg. Our analysis delivers precisions of $\leq 0.1\text{‰}$ for $\delta^{13}\text{C}$, $\leq 0.15\text{‰}$ for $\delta^{15}\text{N}$ and $\leq 0.3\text{‰}$ for $\delta^{34}\text{S}$. We also show linearity data on a sample weight range from 0.5 mg to 2.5 mg of bone collagen. Our method serves to demonstrate routine sulphur analysis on bone collagen samples and provides for the wider application of simultaneous $\delta^{13}\text{C}$, $\delta^{15}\text{N}$ and $\delta^{34}\text{S}$ analysis in ecological and archaeological research.

MT511BB

Biogeochemical cycles and global change

Poster presentation Monday 30 July 2018

The role of log mat biofilm in the Spirit Lake ecosystem after the eruption of Mount St. Helens

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Spirit Lake, on the flanks of Mount St. Helens, was dramatically altered as a result of the eruption in 1980, and over the past 37 years the lake ecosystem has recovered in a rapidly evolving volcanic landscape. While Spirit Lake is similar in many ways to other alpine oligotrophic lakes, it is unique because approximately 20% of the lake's surface remains covered with floating log mats from trees felled during the eruption. The undersides of the logs provide a substrate for biofilm (periphyton) that is primarily comprised of algae, diatoms, and cyanobacteria. Due to the sheer amount of log-based surface area available to biofilm, it is an important and novel part of the lake energy and nutrient cycles. Pilot data sets of invertebrate abundance and diversity suggest that log mats host a robust food web, that is likely supported by biofilm productivity. As well, a range of biogeochemical data collected from various parts of the lake ecosystem (water samples, primary producers, suspended sediment traps, lake bottom sediments) show that biofilm is a distinct and identifiable source of organic material. Here we use carbon and nitrogen elemental and isotopic data collected from sediment cores to investigate both spatial patterns in biofilm-derived organic material in sediments, and temporal changes in amount and source of organic material in sediments. Areas of the lake that are most frequently occupied by the floating log mats (determined by prevailing winds) have the highest nutrient load, and the greatest relative contribution of biofilm-derived organic material. This appears to be a relatively recent pattern, as older sediments have very low organic content. Combined, these spatial and temporal data sets provide insight into how the post-eruption Spirit Lake ecosystem continues to evolve, and the dynamic role of log mat resources.

QF614NR

Isoscapes and movement ecology

Poster presentation Monday 30 July 2018

Linking consumers' isoscapes to modelled primary production in the English Channel

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Primary consumers are a key link of food-webs, funnelling energy from primary production to higher consumers. To better inform benthic-pelagic linkages in the English Channel, an important fisheries area, we investigated the first step of energy transfer between pelagic production and benthic primary consumers over a large geographic scale. Suspension-feeders are good integrators of the sources of organic matter and are directly impacted by changes in primary production origins and benthic-pelagic coupling. The isotopic signatures of their flesh should also reflect the isotopic signal of the primary nutrient source. This study aims to determine how the isotopic signals of widespread benthic suspension-feeding species from the English Channel are linked to the biological and physical oceanographic patterns predicted by the MARS3D model (namely salinity, temperature, chlorophyll-a, diatom and dinoflagellate nitrogen content), over a period relevant with the tissues' turn-over of these consumers. Four bivalves (*Glycymeris glycymeris*, *Aequipecten opercularis*, *Timoclea ovata* and *Politapes rhomboides*) were sampled over the whole English Channel in 2012 and 2014, and their isotopic spatial changes ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) were compared with features of water mass predicted from the model. Since the model indicated differences in physical and biological parameters between the two periods, bivalve isotopic data were analysed separately. Isoscape maps displayed that bivalve $\delta^{15}\text{N}$, and to a certain extent $\delta^{13}\text{C}$ values, were higher towards the east of the English Channel, close to the Seine estuary than to the west or north. Despite of the lack of statistical correlation, the oceanographic contour maps from the MARS3D model also showed higher chlorophyll-a production closer to the Seine River than elsewhere in the English Channel, suggesting high levels of nutrient enrichment from the Seine and that extent of river plumes can be detected in benthic suspension-feeders. This study also aims to determine the level of niche overlap and therefore potential competition among co-occurring bivalve species over this region. While some statistical differences existed among the four species, there was a high level of niche overlap with all species feeding on diverse food sources as evidenced in the broad isotopic range.

BH389QR

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Trophic study of the Southern King Crab *Lithodes santolla* in the Cape Horn Archipelago based on stomach content and carbon-and nitrogen-stable isotopes

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The king crab *Lithodes santolla* is one of the most economically fishery important species in southern waters of the Atlantic and Pacific Oceans, found mostly in deep, and shallow waters. The purpose of this study was to determine diet by stomach content analysis, to use carbon and nitrogen stable isotopes to provide insights into the trophic ecology and to determine the seasonal variation of the diet of the king crab in Nassau Bay, Cape Horn from samples collected during September and November 2017. Our results show that king crab play an important role in the ecology of the Cape Horn area since it was found a wide variety of food items on the stomach content. A variation was observed in the contribution of different prey to the king crab diet between the study time. King crab feed mainly on fish, bryozoans, crustaceans and hydrozoans in winter time and crustaceans, fish, bivalves and alga in spring time. According to stable isotopes analysis, king crab had mean values of -14.8 in $\delta^{13}\text{C}$ (SD=0.8) and 11.5 in $\delta^{15}\text{N}$ (SD=0.4) from 30 samples collected in winter time and mean values of -14.7 in $\delta^{13}\text{C}$ (SD=0.7) and 11.6 (SD=0.4) from 58 samples collected in spring time. Seasonally, there were no significant differences in mean values of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ of the king crab. Furthermore, isotopic analyses suggest significant changes in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ between adults and juveniles due to changes in the trophic habits. However, our study indicates that the trophic position of *L. santolla* may not vary between juveniles and adults, suggesting that king crab does not undergo to a shift in trophic position. Additionally, this study indicated that the contribution from kelp *Macrocystis pyrifera* carbon played an important trophic role as main food source in the food web for this system. This study is the first attempt to characterize trophic structure and relationships of the southern king crab in this area and contribute to state and local fisheries management of this resource, in the context, of generate more data to help ensure the long-term sustainability of the king-crab population and harvest.

Instituto de Fomento Pesquero (IFOP) under the project "Programa de Seguimiento de las principales Pesquerías Nacionales, año 2017. Pesquerías de Crustáceos 2017/2018". "Dieta y rol trófico de la centolla *Lithodes santolla*"

BJ661PG

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Isotopic evidence of structuring killer whale groups along the Southwestern South Atlantic Ocean

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Killer whales (*Orcinus orca*) are large marine top predators that inhabit all oceans and are highly mobile. Despite being the most conspicuous top predator in the Southwestern Atlantic Ocean (SWAO), little is known about their ecology in the region. Here, we used carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope analysis of bone collagen ($n=10$) and dentine tooth ($n=3$) from killer whales stranded between 28°S to 45°S during the period 1970-2014 to assess the trophic ecology of this species over the Patagonian shelf. Muscle and skin of potential prey from the region were also isotopically analyzed. Isotopic values of paired bone and tooth samples from 4 individuals were not significantly different, hence samples were pooled. After correcting $\delta^{13}\text{C}$ values to account for the Suess effect, Discriminant Analysis of Principal Components identified three distinct groups. Group 1 (Patagonian group, $n=8$) included animals with high $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values that after correcting for trophic discrimination factor ($\delta^{13}\text{C}=4.5$, $\delta^{15}\text{N}=5$) fitted with isotopic ratios of their potential prey over the Patagonian shelf, mainly pinnipeds, cetaceans, sharks and large bony fishes. In contrast, the two remaining groups had $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values that do not correspond with the potential prey from the Patagonian shelf, suggesting that they were foraging mainly in adjacent ecosystems. Group 2 (Subtropical group, $n=3$) is characterized by individuals with low $\delta^{15}\text{N}$ and high $\delta^{13}\text{C}$ values that corresponded with the isotopic values reported for killer whales stranded in southern Brazil. Group 3 (Subantarctic/Antarctic group, $n=2$) were individuals with low $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values, which are typical from high latitude waters. The presence of killer whales trophic groups over the Patagonian shelf suggests the existence of structuring subpopulations exploiting specific habitats. Moreover, one of the individuals from the Patagonian group shares haplotype with conspecific from Subantartic/Antarctic waters, revealing some degree of connectivity between populations among these large marine ecosystems. Nonetheless, population genetic studies are needed to confirm the population structure and migration along SWAO. Our results further the scarce ecological knowledge for the species in the region, while presents the basis to infer more complex ecological hypothesis.

BQ869RP

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Trophodynamics of ichthyo- and mesozooplankton from Chiloé's inner sea (Northern Patagonia) based on C and N isotopes

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In Chiloé's inner sea (41° S, 73° W to 43° S, 73° W), the abundance and composition of zooplankton is seasonally determined by primary production (higher in spring and lower in winter) and the dominant type of food web (microbial vs classic). Along with this, changes in freshwater input from rivers and ice melting occur between seasons, which might modify the organic carbon isotopic signature of plankton assimilated by the ichthyoplankton feeding stages and the eggs of adult fish reproducing in the area. In this study, mesozoo- and ichthyoplankton were collected at Fiordo-Seno del Reloncaví and Golfo Ancud, and at an extra station off Boca del Guafo in winter in order to compare inshore and offshore individuals. Samples from the inshore zones were also collected in spring to compare between seasons. Combined carbon and nitrogen stable isotope analyses ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) were used to quantify trophic structure of the most abundant larvae of fish species: *Sprattus fueguensis*, *Engraulis ringens*, *Strangomera bentincki* (Clupeidae), *Maurolicus parvipinnis* (mesopelagic species), and *Sebastes oculatus* (demersal species), along with eggs of *M. parvipinnis*, particulate organic carbon and mesozooplankton. Expected results should show higher abundance of omnivorous and carnivorous zooplankters than herbivorous in winter, and the opposite in spring. Temporal variability and composition of fish larval assemblages should occur in response to food availability dependent on the temporary changes in productivity, and also in the larval trophic positions (TP) and in organic carbon isotopic content according to the origin of the organic carbon source (terrigenous vs. oceanic). Particulate organic carbon might be more enriched in $\delta^{13}\text{C}$ during the winter (higher terrigenous input) than during the spring. Expected results of $\delta^{15}\text{N}$ should give differences between both seasons due to the microbial and classical food web alternation. Offshore fish larvae in winter should have a wider trophic niche breadth and lower TP than inshore fish larvae (where the microbial web dominates in winter). Shallow-dwelling larvae in inshore waters should experience the strongest seasonal variation, in agreement with changes in freshwater inputs (determined from $\delta^{13}\text{C}$), when comparing with deeper water-dwelling larvae (inshore and offshore) that reside in more stable oceanic waters.

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Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Landscape modification on the food web structure of Neotropical streams

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Headwater streams trophic structure is intimately related to the energy input from adjacent ecotones. In this study, using stable isotope analysis, we investigated trophic diversity, primary producer isotopic signatures and basal resources supporting consumers in Neotropical streams under a degradation gradient of land use change. Primary sources, invertebrates and fishes were sampled in two forested streams, three streams under sugar cane influence, two with pasture and two urban streams. Trophic diversity of fishes and invertebrates was similar and high in the most preserved forested stream, with high trophic level consumers sustained by allochthonous particulate organic matter (POM) and basal resources with ¹⁵N signatures between 2 to 7‰. The most degraded stream (i.e. urban) presented low trophic diversity. Primary sources were ¹⁵N-enriched (~16‰) and high trophic level consumers were sustained by autochthonous POM (i.e. algae). Intermediary-impacted streams (i.e. sugar cane and pasture) presented variable trophic structure, with values inside the range registered from forested and urban streams. Trophic structure of the extremes of our degradation gradient (i.e. forested and urban) reflected (a) the positive effects of local habitat quality and (b) the negative effect of spates and nutrient enrichment, while food web structure of intermediary-impacted streams reflected the variability of combinations of local factors. Food web structure of the headwater streams was altered by anthropogenic land use in their watershed, and the mechanisms underlying food web structure responses are intrinsically related to local physical habitat features.

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Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Trophic relationships between co-occurring benthic suspension-feeding species, a matter of scale?

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The invasive slipper limpet *Crepidula fornicata* is a filter-feeding gastropod which is a potential trophic competitor when present in large densities. As habitat forming species, it also facilitates the installation of other suspension feeders through the physical presence of large accumulation of shells. Its biological activity (e.g. biodeposition) also modifies the surrounding environment, by increasing organic matter content in the sediment and stimulating subtidal microphytobenthos (MPB), a probably underestimated food source. Among co-occurring species, some are sessile epibionts closely associated to the shells of slipper limpet and others - including species of economic interest - are located in the near-field of *Crepidula* stacks. In this study, we investigated the trophic interactions between *Crepidula fornicata* and the co-occurring suspension feeding species in dense *Crepidula* banks of the Bay of Brest (France). We assess the degree of feeding strategy overlap between species at two spatial scales: the millimetre scale, between the slipper limpet and two epibionts species (the Calyptraeidae *Calyptraea chinensis* and the barnacles *Austrominius modestus*); the meter scale between the slipper limpet and two commercial species (the scallop *Mimachlamys varia* and the oyster *Ostrea edulis*). Trophic web studies using only bulk stable isotope analysis (SIA) struggle to disentangle food sources contributions. Yet benthic suspension feeding species exhibit variable capabilities to select their food. Among these potential food sources, MPB growing at the sediment water interface is often lacking in trophic budget of primary consumers, especially because it requires challenging sampling techniques. One way to accurate our understanding of food sources assimilation is to couple different trophic markers. In this study, we performed triple trophic markers analysis (SIA, fatty acid (FA) and compound-specific stable isotope analysis), on a fast turnover tissue (digestive gland), to better assess the trophic role of MPB. We also used a new trophic niche analysis based on both SIA and FA signals to infer about the nature of trophic interactions (competition, facilitation) between *Crepidula fornicata*, epibionts and shellfish species over two consecutive seasons (winter and spring).

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Isotopic niche differentiation between bottlenose dolphin ecotypes of the western South Atlantic

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Ecological variability is important to allow coexistence of species and populations. If large enough, it can promote reproductive isolation and divergences among populations. Bottlenose dolphin populations can exhibit a wide variety on diet and foraging behavior. Two common bottlenose dolphin ecotypes – coastal and offshore – are recognized worldwide. Recently, morphology and genetics confirmed these forms in the western South Atlantic (wSA). However, ecological queries such as the degree of overlap in diet or resource partitioning between both ecotypes remain unexplored. To fill this gap, we analysed stable isotope compositions ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) of tooth dentine collagen of 10 coastal and 13 offshore specimens from wSA. To estimate metrics of isotopic niches we calculated the standard ellipse area corrected for small sample sizes (SEAc) and their overlap area through SIBER (Stable Isotope Bayesian Ellipses in R). No statistical differences were detected between ecotypes for both $\delta^{13}\text{C}$ (coastal = $-13.4 \pm 1.1\text{‰}$; offshore = $-13.9 \pm 1.2\text{‰}$) and $\delta^{15}\text{N}$ (coastal = $15.9 \pm 1.4\text{‰}$; offshore = $16.6 \pm 1.6\text{‰}$) values. The SEAc for the coastal ecotype was 5.08‰^2 and for the offshores was 5.20‰^2 . The ellipses exhibited an overlap area that represents 50% of the coastal and 49% of the offshore isotopic niches. These results show a degree of niche overlap, which is in accordance with the proposal of a spatial contact zone and a parapatric distribution. Further studies evaluating the isotopic niche along ontogeny will allow the investigation of niche partitioning among age classes within the species ecotypes in wSA.

QR249HQ

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Identifying the resource use of larval sea lamprey in their native habitat – novel insights from a four isotope approach

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Sea lamprey, *Petromyzon marinus*, are amongst the most ancient, iconic and mysterious fish species on the planet. Lamprey are characterised by a complex life history which involves spending 2-8 years as larvae (ammocoetes) living within the sediment in clear water rivers, during which time they are believed to filter feed on detritus in the water column, before metamorphosis and migration to sea or lakes where they feed as external parasites of coastal fishes. Chastised as an invasive species in the North American Great lakes regions and threatened to the point of local extirpation across much of their native range understanding this species presents several unique challenges in obtaining samples from native habitats. In order to better identify the resource use and trophic position of larval sea lamprey (ammocoetes), we examined carbon, nitrogen, hydrogen and oxygen stable isotope ratios of lamprey from three rivers in New Brunswick, eastern Canada. In addition to lamprey, we sampled and analysed allochthonous and autochthonous primary producers, all available invertebrate functional feeding guilds and dominant fish species at each site. We used stable isotope mixing models to identify the resource use of lamprey in relation to sympatric invertebrate and vertebrate consumer guilds. Ammocoete lamprey occupied a unique niche within all rivers. Their isotope ratios were strongly indicative of allochthonous resource use, supporting their previous classification as detrital filter feeders. However, their isotopic niche was distinct from other known filter feeding (e.g. bivalve mussels) or collector-gatherer taxa (e.g. chironomids). This is possibly indicative of foraging within the hyporheic zone, but additional baseline sampling including this often-overlooked habitat will be required to test this hypothesis.

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Stable isotope analysis reveals varied foraging strategies and the importance of red algae in the diet of *Chelonia mydas* in the north of Chile

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The presence of *Chelonia mydas* in Northern Chile has long been noted, but data are lacking regarding their role in the region's coastal ecosystem. Here, we used bulk carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) stable isotopes to characterise long- (skin) and short-term (whole blood) foraging patterns of turtles collected from Playa Chinchorro, Arica. Stable isotope values of primary-producers and invertebrates from the coastal zone of Northern Chile were used to characterise turtle trophic ecology. Bayesian models were used to estimate the contribution of different putative prey groups and to provide robust estimates of trophic-position (TP). Black turtles showed little variation in $\delta^{13}\text{C}$ (blood: -18.8 to -16.5‰; skin: -16.9 to -15.2‰) but $\delta^{15}\text{N}$ values ranged considerably (blood: 13.1 to 21.3‰; skin: 14.5 to 22‰). Turtles were notably ^{13}C -depleted relative to several putative prey groups including *Ulva*, kelp and grazing-gastropods. $\delta^{15}\text{N}$ values showed the apparent existence of two different foraging-strategies: a low- $\delta^{15}\text{N}$ group (values <20‰) and a high- $\delta^{15}\text{N}$ group (≥ 20 ‰). This split in $\delta^{15}\text{N}$ was associated with mtDNA haplotype, with H1 individuals largely being found in the high- $\delta^{15}\text{N}$ group, while H2 individuals were found in the low- $\delta^{15}\text{N}$ group. Mixing models indicated that diets varied both between the different $\delta^{15}\text{N}$ groups, and over time. The long-term diet (indicated by skin isotope data) of both $\delta^{15}\text{N}$ groups was dominated by red algae (median: low- $\delta^{15}\text{N}$ = 80 %; high- $\delta^{15}\text{N}$ = 56 %), but the high- $\delta^{15}\text{N}$ group also consumed bivalves (22 %) and jellyfish (10 %). Blood (an indicator of more-recent diet) indicated that the low- $\delta^{15}\text{N}$ group were largely consuming red algae (70 %), while the high- $\delta^{15}\text{N}$ group had consumed animal prey including bivalves (50 %) and jellyfish (15 %), as well as red algae (8%). Bayesian estimates of TP indicated that the low- $\delta^{15}\text{N}$ group had a TP of ~ 2.1 and the high- $\delta^{15}\text{N}$ group a TP of ~ 2.7 , indicating consumption of increased amounts of animal prey.

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BR332MN

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Stable isotopes and stomach contents analysis reveal complete niche partitioning between invasive juvenile rainbow trout and the endemic cyprinodontid *Orestias chungarensis* in the Río Chungará, N Chile.

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Lago Chungará is located high (4500 masl) in the Chilean Altiplano and is an unusual ecosystem, reflecting its altitude and remoteness. Its fish community historically consisted of a single endemic - *Orestias chungarensis*, a small-bodied cyprinodontid. However, rainbow trout (*Oncorhynchus mykiss*) were introduced ca. 20 years ago. Trout are both potential competitors and predators of *Orestias*. There is a pressing need for more information on the status, ecology and role of *Orestias* in the lake's function and the consequences of the trout introduction. However, the remote/extreme nature of Lago Chungará means that routine sampling is difficult, dangerous and expensive. *Orestias* are endangered, limiting the capacity to characterise their diet using traditional (but fatal) stomach content analysis, which only provides a snapshot of recent feeding. To understand long-term feeding patterns and trophic interactions with invasive trout it would be necessary to repeatedly sample over time. As this is not possible given logistic and ethical considerations, we used stable isotope analysis (SIA of C and N of *Orestias* and rainbow trout from the Río Chungará to compare short-term (SCA) trophic and long term (SIA) isotopic niches.

Results showed that both the trophic niche (SCA: short-term foraging) and isotopic niche (SIA: long-term) of the two species were distinct. Although both species consumed large amounts of chironomids larvae (ca. 40 % by volume in both species), trout had a more diverse diet consuming adult aerial insects, and a range of aquatic insect larvae (Plecoptera, Ephemeroptera, Trichoptera) and pupae, while *Orestias* had a less diverse diet, and consumed amphipods and benthic cladocerans in large amounts. Isotopically, the two species had similar $\delta^{13}\text{C}$ values, but *Orestias* were significantly ^{15}N -enriched relative to trout by ca. 2 ‰, and their SEAB ellipses did not overlap. Trout (SEAB = 6.8 ‰²) were isotopically much more variable compared to *Orestias* (SEAB = 1.5 ‰²). By comparing both approaches, it is apparent that when found in sympatry, *Orestias* and trout had distinct diets. What is not clear however is whether the current diet of *Orestias* reflects its natural trophic niche or a diet shift following the introduction of rainbow trout.

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Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Using stable isotopes to assess the utility of fatty acids biomarkers of pelagic and benthic resources in kelp-forest fishes

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A range of different biochemical markers are commonly used to assess the relative contribution of different energy sources to consumers, including stable isotopes and fatty acids. We compared the utility of the two approaches as indicators of the presence, and scale of energetic subsidy by pelagic-derived materials to benthivorous fishes from coastal kelp forests in N Chile. Recent work using stable isotopes has shown that this fish assemblage is largely (>90 %) fuelled by pelagic-derived carbon originating from coastal upwelling. We examined $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in three abundant benthivorous fishes, as well as in indicator taxa for pelagic (filter-feeding bivalves) and benthic (grazing gastropods) derived energy from kelp forest habitats in Antofagasta. We also estimated concentrations of essential fatty acids routinely considered as biomarkers for pelagic or benthic-derived energy in the fish. We then examined whether there was a predictive relationship between the percentage of pelagic-derived C in fish tissues (based on 2-source mixing models) and the concentration of key pelagic and benthic fatty acid biomarkers in ovary and muscle tissues, as might be expected given the routine use of these markers to estimate energy flow in marine food webs.

Fish stable isotope values were similar between the three species, and lipid-free fractionated-adjusted $\delta^{13}\text{C}$ values were ^{13}C depleted relative to gastropods grazing on kelp and other benthic primary producers but were more closely associated with phytoplankton-feeding bivalves. A simple 2 source mixing model indicated that fish were largely pelagic-fuelled, using both muscle and ovaries. Fatty acid analysis showed that essential fatty acid profiles were dominated by pelagic-associated biomarkers supporting our evidence from SIA that pelagic-derived energy fuels these fish. However, there was no evidence that the concentrations of individual essential fatty acid biomarkers were related to the proportion of pelagic (or benthic) C assimilated by the fish. This raises the question whether fatty acid analysis can be used to provide a quantitative assessment of contributions of different sources of energy, or simply provides a qualitative indication.

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CN464HS

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Using isotopic niche metrics to assess responses by soft-bottom macrobenthos to natural oscillations in dissolved oxygen concentrations in a upwelling-associated oxygen minimum zone.

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Over-exploitation of resources, habitat loss and habitat modification have typically been identified as the main stressors of marine environments. However, during the last century, hypoxia (oxygen depletion in aquatic environments) has become of increasing interest, since oxygen is a key element supporting metabolic processes, and has shown a decrease in concentrations in coastal and oceanic zones, worldwide. The development of hypoxia leads to important ecological and economic consequences, including reductions in biodiversity, potentially resulting in changes in the complexity of food webs and energy flow within the system. However, in highly productive upwelling systems, as the Humboldt Current System, hypoxic conditions occur naturally, due the existence of OMZ, which upper boundary in the northern Chile is situated ~50 depth which expand and constrain according to the intensity of the upwelling processes, even reaching very shallow depth (~10m) within Mejillones bay. This is an important issue, considering that climate change predictions suggest that hypoxia will increase due global warming, since oxygen is less soluble in warmer waters. Hypoxia is also predicted to increase due to anthropogenic causes mainly associated to eutrophication induced by nutrient inputs. Here we ask how inshore soft-bottom macrobenthic communities react to changes in oxygen conditions within the system? We characterized and described the isotopic composition ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) of the main trophic functional groups of the macrobenthos in a depth gradient (10, 20, 30 & 50m) inhabiting a soft-bottom system in Mejillones Bay, N Chile (ca. 23°S) over two years. We examined how the isotopic niche of different trophic functional groups varied with depth, season, and dissolved oxygen conditions using SIBER (SEAc & Layman statistics) and tRophicPosition (trophic position). Results showed that isotopic variation was driven more by temporal factors than by depth. However, SIBER analysis generally showed a wider isotopic trophic niche in shallow compared to deeper habitats in most groups apart from filter feeders and subsurface filter feeders.

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Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Using stable isotopes derived trophic position to improve mass-balanced food web models

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Food web modelling has become an important research field in marine ecology and a tool for decision making in fisheries management. The “Ecopath with Ecosim” approach (EwE) is widely used to represent trophic relationships among different groups or species within a given assemblage. However, with fish, these models are usually based on stomach content analyses and bibliographic data about diets in similar environments (with its associated biases and drawbacks), and usually “similar” species are pooled together into homogeneous or functional groups in order to have an average representation of their diet and trophic connectivity. In this study, a published EwE model of San Matías Gulf demersal community associated to hake was analysed and the trophic levels (TL) of its functional groups were calculated. On the other hand, using stable isotopes data and a Bayesian modelling approach (by means of the tRophicPosition package in R) the individual trophic position (TP) of several species of the demersal community were calculated. The objective was to compare the results of these modelling approaches in order to detect differences in the TL/TP of the species within each functional group. The range of estimations of TL by EwE was wider (2.02 ; 4.64) than the estimations of TP by stable isotopes (3.32 ; 4.49). The highest TL estimated was for the large Argentine hake (TP=4.02, TL=4.64), while the highest TP estimated was for the Angular angel shark (TP=4.49, TL=3.62). On the other hand, within functional groups of lower TL, estimations of TP were higher than estimations of TL values, while in functional groups of higher TL, the estimated TP were lower than the estimated TL values. Also, as expected due to the methodology used to pool species together in EwE, there was a variability in the estimated TP within some functional groups (e.g. medium-sized sharks, flounders), while others showed homogeneous estimations of TP (e.g. small rays, squids, hakes). Our results show that stable isotopes can provide useful information to improve the models developed with EwE, in order to achieve a better understanding of the ecosystem.

CH326CQ

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Plankton food-web pathways to juvenile salmon.

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Salmon are one of the most relevant fish in the North Pacific but their stocks in Canada have been declining since the 1990s. It is thought that total survival of salmon is correlated to early marine survival. Marine food-web processes have a major role in the survival of juvenile salmon because the quantity and quality of zooplankton prey available to juvenile salmon has a direct impact on their growth and condition. The juvenile fish of most of the Pacific salmon populations in Canada enter the ocean into the southern area of the highly productive Strait of Georgia (SoG), and then the fish start migrating north. Oceanographic conditions in the SoG have shown dramatic variability over the past few decades. However, the interactions between environmental variables and zooplankton in the SoG remains poorly understood. Trophic dynamics of early marine salmon migratory routes in the SoG is therefore expected to be critical for the survival of the fish. This study aims at explicitly identifying the zooplankton responses to changing phytoplankton bloom timing and phenology and at determining the plankton food-web pathways to juvenile salmon, as well as their annual (2008-2017), seasonal and spatial variability in the SoG. Food-web pathways will be described using Bayesian mixing modeling of bulk $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ analysis. Moreover, we will use $\delta^{13}\text{C}$ of individual amino acids to accurately identify the primary producers fueling the trophic dynamics of migratory animals such as salmon and to distinguish metabolic relationships in the food-web from changes in isotopic compositions at the base of the food-web. We anticipate that bottom-up processes in the SoG – including seawater warming, spring phytoplankton bloom timing and zooplankton community composition – are defining the survival of early marine salmon. This study represents the first attempt to biochemically determine food-web pathways that will be explicitly compared with historical data on zooplankton composition and juvenile salmon diets in the SoG. Additionally, the expected outcomes will allow us to make inferences about long-term changes in the plankton food-web dynamic and impacts on juvenile salmon.

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Isotope ecology from individuals to communities A
Poster presentation Monday 30 July 2018

On the geometry of the isotopic niche

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Direct measures of variance and centrality in isotopic space are now commonly used as surrogates for population-level trophic niches in ecological studies. When comparing two or more populations, separation in isotopic means are inferred as differences in niche occupancy and disparities in variances taken as differences in niche width. However the degree to which stable isotope compositions directly reflect trophic niches has been poorly resolved, an issue that we address using a theoretical, bottom-up approach.

We first identify the geometric properties of both the trophic niche space and isotopic space and describe the mapping between these two spaces. We then use simulations of individuals drawn from defined population-level average diets to test for statistical differences in both trophic niche space and isotopic space. By varying the comparative population diet distributions and fixing all other potential sources of isotopic variation other than diet, we show that the ability to differentiate populations in isotopic space is dependent upon the diet structures of the populations of interest. The sensitivity of isotopes is shown to decrease with increasing dimensionality and diet variation, yet even in fully determined systems isotopes can fail to separate statistically distinct diet structures. Interestingly, although rare in our simulations, separation in isotopic space can occur when the population trophic niches are not statistically different.

These preliminary results indicate that care should be taken when interpreting niches directly from stable isotopes, which are compounded by many other sources of variation in real-world data, particularly if dietary sources are unknown.

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Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Influence of environmental conditions on Antarctic Notothenioid trophic ecology in a context of global climate change

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The Southern Ocean currently undergoes major environmental modifications related to climate change such as changes in the sea ice cover, temperature and acidification. When faced with environmental changes, all organisms are expected to have some intrinsic capacity to adapt their ecological habits to their new life conditions. Currently, biological traits of many Antarctic species are still unknown and we need such information to assess their capacity to adapt to natural and anthropogenic perturbations. Notothenioidei (Perciformes), or icefishes, are endemic to the Southern Ocean and they are an important trophic component of these marine ecosystems. To better understand their resources partitioning and the influence of environmental changes on their trophic ecology, we used muscle stable isotopes ratios of carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) of two widespread genera of icefishes (*Trematomus* and *Lepidonotothen*) sampled in 2002/2004 and/or in 2015/2016. Isotopic niches (which are a proxy of the realized ecological niches) were modeled using the SIBER (Stable Isotope Bayesian Ellipses in R) R-package. For the two sampling periods, our results revealed a great variation in isotopic compositions among Notothenioid fishes, suggesting that they exploit a wide array of resources. The overlap between the isotopic niches of *Trematomus* and *Lepidonotothen* genera in 2002/2004 highlights a possible past competition for resources. Moreover, temporal evolution of niches suggests taxon-specific ecological plasticity in response to variation in environmental parameters and/or in prey availability. An increase in resources partitioning between the two genera was observed over the studied period. In the future, it would be interesting to complete our results with a stomach content analysis and to use mixing models including isotopic composition of potential preys to identify possible changes in their trophic ecology.

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DD311BD

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Host feeding ecology and trophic position significantly influence isotopic discrimination between a generalist ectoparasite and its hosts: implications for parasite-host trophic studies

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Despite being one of the most prevalent forms of consumerism in ecological communities, parasitism has largely been excluded from food-web models. Stable isotope analysis of consumers and their diets has been widely used in the study of food-webs for decades, but the amount of information regarding parasite stable isotope ecology is limited. This study took advantage of distinct differences in the feeding ecology and trophic position of different species of fish known to host the same common micropredatory gnathiid isopod, to study the effects of host stable isotope ecology on that of the associated micropredator. As expected, blood engorged gnathiids were in most cases indistinguishable from their hosts' blood, but significant isotope fractionation occurred as they molted into adults. Adult male gnathiids were generally lower in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ than blood from their respective host species whereas host specific isotopic discrimination for females varied among the different host species. Our model also predicted that there is a significant effect of host blood $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ on the rate of stable carbon and nitrogen (respectively) isotopic discrimination between gnathiids and blood from their host. As such, general differences in the feeding ecology and trophic positions of the different host species were reflected in their associated gnathiids, indicating that stable isotope analysis of wild caught gnathiids can provide significant details concerning previous hosts. The results present herein have significant implications for how stable isotopes may be used as a tool to study the trophic dynamics and feeding ecology of gnathiids.

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Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Following the food sources and trophic ecology of an Antarctic coastal benthic community

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The relative importance of the assimilation of benthic versus pelagic food sources by consumers, remain poorly understood in most Antarctic ecosystems, and therefore, it has been difficult to predict how climate change will impact the trophic interactions of benthic communities via changes in the utilization of energy channels. Low and upper trophic level consumers from Fildes Bay (South Shetland Island, Antarctic Peninsula)—a dynamic ecosystem —were studied using stable isotope and Bayesian statistical approaches to explore both, trophic links between basal production sources (snow ice algae, macroalgae, periphyton, particulate organic matter in sediment and pelagic) and to quantify trophic redundancy with standard ellipse areas among trophic guilds levels. Roughly 22 taxa were collected during 15 sampling events during summer 2017 within the Bay. The output of SIAR confirmed different proportions of assimilation of benthic and pelagic food sources by consumers, suggesting that particulate matter pelagic was of limited dietary importance, and instead, macroalgae and particulate organic matter in sediments were the dominant energy channels, especially to upper level consumers. Nonetheless, some predators like *Nothotenia coriiceps* and *Odontastes validus*, exhibited multiple energy channels from different sources coupled to the largest SEAs measured. This coupling indicates resilience to alterations in food resources and stability in the food web, however, the utilization of specific energy channels by some consumers reinforce the need to account the interannual trends in primary production regime to assess the stability of benthic Antarctic communities.

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DP421TB

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Effect of locomotion habits and structural complexity of vegetation in the trophic niche of communities of small mammals of the Central Brazilian Savannas

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Small mammals have different adaptations to the use of space that can diversify strategies for exploiting food resources. We investigate through the isotopic assimilation of the resources, the relation between habit of locomotion and trophic level of these animals from the Central Brazilian Savannas (Cerrado). We evaluated whether small mammal species scansorial-arboreal (SA) are more frugivorous than exclusively terrestrial species (TE). This is due to the greater accessibility to plant resources for SA and also because the capture of invertebrates is facilitated in the soil, leading to greater insectivorous by TE. We also investigated the relation of structural complexity of the vegetation with isotopic niche of the species of forest, savanna and grassland vegetation formation from the Cerrado. We hypothesized that trophic diversity of the species of each formation will follow the structural complexity gradient of the vegetation, being higher in the forest, intermediate in the savanna and smaller in the grassland. We captured the (365) small mammals and evaluated the availability of food (e.g., zoocoric fruits and terrestrial invertebrates) in the rainy season and dry season between in those three vegetation formations. We used the $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ of the hair of those small mammals (124 samples) to evaluated the isotopic niche as well as the potential food resources. The SA was frugivorous, while the TE was more insectivorous. In this way, the locomotion habit is related to the ease of capture of potential foods, influencing the preferential food resources. In addition, the amplitude of the isotopic niche of the communities of each vegetation formation followed the vegetation complexity gradient, being greater in the formation of the forest, followed by the savanna and smaller in the grassland. The forest areas also presented greater packaging of the isotopic niche. Thus, places with greater possibilities of food resources (i.e., forestry) seem to provide a larger subdivision of the niche.

CAPES Coordenação de Aperfeiçoamento de Pessoal de Nível Superior

GC359KH

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Analysis of trophic aspects in *Mustelus mento* (Cope 1877) in the central-northern zone of Chile, by studying stomach contents and stable isotopes

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Studies about interactions between species are a useful tool to understand the biology, role in ecosystems, flow of energy and potential impact of predation of biological resources. Given its high biodiversity, Coquimbo Bay is an important marine ecosystem with a high demand for fish resources. Among the species of commercial interest, is the speckled smooth-hound, *Mustelus mento*, whose landing levels has been considerably reduced in recent years, and is also target by local fisheries. Studying and characterizing the trophic relationships of *M. mento* would make it possible to better understand the ecclesiastical relationships of the study in this area, along with providing relevant information to understand the variations in its landing levels. The objective of this study was to determine the trophic level of *M. mento* and to provide preliminary data on its trophic networks. 14 individuals of *M. mento* were captured in the Bay of Coquimbo. Their stomach content was analyzed, the relative importance index (IIR) and diversity of prey indexes (Shannon-Wiener and Levin) were estimated and stable isotope analysis was carried out, both to the predator and to the recovered preys from the stomachs to determine their trophic levels. 8 species of invertebrates were identified: 4 species of crabs, 2 of sand flea, 1 stomatopod and 1 squid, among which, *Ovalipes trimaculatus* and *Emerita analoga* presented high IIR. The diversity indices were low, indicating that speckled smooth-hound is a specialist predator. In addition, the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values were high, characteristic of demersal and tertiary mesopredator species, respectively. The $\delta^{13}\text{C}$ levels of *M. mento* dams were consistent with feeding from pelagic and benthic organisms. According to the values of $\delta^{15}\text{N}$, the prey of *M. mento* are primary and secondary consumers.

DQ566QC

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

The role of anthropogenic food sources in the diets of urban raccoons (*Procyon lotor*) and Virginia opossums (*Didelphis virginiana*) in the Pacific Northwest, USA

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Several of the most abundant and ubiquitous wildlife species in human-dominated landscapes are mesocarnivores (ie. raccoons, opossums and coyotes). Two urban centers in the Pacific Northwest (Seattle and Tacoma) host large populations of co-occurring raccoons and opossums. We use the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of hair samples to estimate trophic structure and the contribution of anthropogenic food sources (primarily human food waste and pet food) to raccoon (n=40) and opossum (n=26) diets. Corn and sugar cane are both C_4 plants and common in anthropogenic food sources, and naturally occurring C_4 plants are very rare in the region. In addition to the mesocarnivores, we also analyzed hair samples from co-occurring humans (n= 35) and pets (n=10), and used rodent, arthropod, plant and soil samples to characterize the isotopic environment. Our study addressed the following questions; how do raccoons and opossums exploit anthropogenic resources differently and how does the contribution of anthropogenic resources to diet vary within a city? At the species level we found raccoons had significantly higher $\delta^{13}\text{C}$ values, and lower $\delta^{15}\text{N}$ values than opossums, suggesting raccoons consumed more anthropogenic food sources, and were at a slightly lower trophic level. Indeed, raccoon and human/pet $\delta^{13}\text{C}$ values were statistically indistinguishable. Raccoon $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values were more variable among individuals than opossums, possibly indicating a broader range of foraging behaviors. Our data showed opossums do not heavily rely on anthropogenic food sources, and may benefit instead from the physical landscape humans provide both for prey (arthropod) habitat, and den sites. Within the Seattle raccoon population $\delta^{13}\text{C}$ values varied among the different Seattle greenspaces, and sometimes these differences were counter-intuitive. For example, raccoons from the largest Seattle greenspace had the most anthropogenic diet. Within the Tacoma raccoon population, we identified only two individuals with substantial contributions of marine resources to diet, which was also surprising given the shoreline proximity. Finally, despite differences in sampling strategies in Tacoma versus Seattle (road kill in the urban matrix and hair snares in greenspaces, respectively), similarities in raccoon diet between these two populations confirms that we can make generalizations about urban raccoon foraging ecology.

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FJ185DF

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Carbon and nitrogen isotopes trace nutrients from wood on the ocean floor into microbial and animal communities

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The availability of chemical energy and macromolecules needed for tissue synthesis influences the abundance and growth of living organisms, ultimately shaping species interactions and community structure. The ocean floor of the deep sea is a useful environment in which to explore this influence because the absence of light prevents photosynthesis, limiting energy availability. Wood falls, in which pieces of terrestrial wood flushed into the ocean become saturated and sink to the ocean floor, are colonized by unique communities which assemble to exploit this concentrated and rare energy source. We placed experimental wood falls at ~3200 m of depth in the northeast Pacific Ocean, then after 5 years recovered the wood and associated fauna. In comparison to the particulate organic matter (POM) which normally provides nutrients to this environment ($\delta^{13}\text{C}$: -22 to -17 ‰, $\delta^{15}\text{N}$: 2 to 6 ‰), terrestrial wood tends to be lower in $\delta^{13}\text{C}$ (-28 to -25 ‰) and $\delta^{15}\text{N}$ (0 to 3 ‰). The keystone taxa of wood fall communities, wood-boring bivalves (*Xylophaga* spp.) that transform recalcitrant wood carbon into more bioavailable forms, exhibited $\delta^{13}\text{C}$ of -23.4 ‰ (± 0.4 SD) and $\delta^{15}\text{N}$ of -0.4 ‰ (± 0.4) in our experiment, suggesting they obtained most of their carbon and nitrogen directly from the wood fall. Tanaids, small crustaceans, had $\delta^{13}\text{C}$ (-23.7 ± 0.4) and $\delta^{15}\text{N}$ (3.2 ± 1.4) which suggested that they consumed *Xylophaga* waste products and detritus. More mobile consumers such as gastropods, polychaetes, and Galatheids (small crabs) had slightly higher $\delta^{13}\text{C}$ (-22.5 ± 0.7) and $\delta^{15}\text{N}$ (5.4 ± 1.3) suggesting that they were secondary consumers of material derived from both the wood fall and POM. Currently we are measuring $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in individual amino acids to confirm differences in baseline values for wood versus POM, quantify food-chain length across variable wood fall size, and resolve the ultimate fate of amino acids synthesized at the base of the food chain. Specifically, the patterns in consumer essential amino acid $\delta^{13}\text{C}$ will reveal whether they are harvested directly from wood, synthesized by bacterial mats, or produced by microbes in symbiosis with multicellular animals.

FQ975PQ

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Isotopic assessment of benthic periphyton under open canopy and nutrient enrichment in shaded oligotrophic streams of Central Brazil

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Although there is little knowledge about the benthic periphytic in neotropical riparian forests, the factors that limit periphyton biomass (e.g. light and nutrient enrichment) is central to understand energy flow in stream ecosystems. A previous meta-analytical study showed that at local spatial scales, periphyton $\delta^{13}\text{C}$ was negatively related to canopy cover and positively related to chlorophyll-a density. Thus, periphyton collected in the open canopy areas has higher $\delta^{13}\text{C}$ values compared to the closed canopy areas in neotropical forest streams. In order to test this pattern, the benthic periphyton was experimentally manipulated in shaded and open canopy in four streams with different nutrient concentrations located in the Environmental Protection Area Gama and Cabeça de Veado streams, in Central Brazil. Four streams (two nE and two pristine) were selected where an unglazed ceramic tile was used for periphyton colonization (10x10 cm). Grazing invertebrate's tiles colonization were prevented by using high-voltage electric pulses. These tiles were deployed in open and shaded (80% canopy cover, respectively) patches of stream bed. Two of the four streams have high nutrients concentrations. The riffle/glide habitats were chosen with similar flow, depth and substrate properties. After 2-weeks, periphytic chlorophyll-a, ash-free dry mass (AFDM) and carbon and nitrogen stable isotopes ratios were determined. In general, those analyzed parameters were higher in open patches and in the enrichment nutrient streams than in closed patches and non-nutrient enriched streams. The streams with lower concentration of nutrients tend to have lower $\delta^{15}\text{N}$ values to high N_2 biological nitrogen fixation (BNF) capacity once cyanobacterias are more abundant in areas with low nutrients. In nutrient enriched streams, the species that do not perform BNF will have advantage and become more abundant, changing the periphyton $\delta^{15}\text{N}$ values. The periphyton under conditions of high light and nutrient enrichment has higher $\delta^{13}\text{C}$ values than those shaded conditions and low nutrients. The carbon and nitrogen stable isotopes associated with AFDM and chlorophyll-a in the benthic periphyton can become an important tool for assess the riparian forest disturbs and input of anthropogenic nutrients to headwater streams.

RUFFORD FOUNDATION (RGS REFERENCE 19719-1)

KM665LN

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Trophic ecology and niche overlap between the invasive American mink and native European mink

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The negative effect of invasive species via direct and indirect interactions with native species is widely recognised. The pressure of invasive species on native species is especially strong as their ecological niche overlap increases, particularly in relation of trophic niche. Diet and niche overlap between the invasive American mink and native European mink was assessed in Spain by nitrogen and carbon stable isotope analyses. Hair samples were used to obtain information on diet of both species in areas where are sympatric with respect to areas where they are allopatric. A high variability in $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values both in allopatric and sympatric European mink populations was registered. The European mink allopatric population showed higher $\delta^{15}\text{N}$ values and lower $\delta^{13}\text{C}$ ones than in sympatry populations with the invasive mink, indicating a diet change between stages of coexistence towards the consumption of a higher proportion of terrestrial prey in sympatry. Similarly, a diet shift in the native mink through the invasion process by the invasive mink was revealed by Bayesian mixing model analyses. Differences between sex were not found between $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values for the European mink both in allopatric and sympatric populations. Similarly, sexes did not differ significantly in their $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values for the invasive mink. Crayfish and birds was predominant in the native mink diet in allopatry, while that in sympatry with the invasive mink, a shift of diet towards more terrestrial prey was detected consuming principally small mammals. A high trophic overlap among invasive and native mink was found when are sympatric, suggesting a potential for trophic competition, which may have important consequences for the management and conservation of the native mink.

The samples used in this study come from different European mink conservation projects carried out by the Government of La Rioja, Diputación Foral de Álava and the Ministry of Agriculture, Fisheries, Food and Environment of Spain.

NR478PD

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Trophic competition and habitat connectivity between shark species from oceanic islands in the Northeastern Pacific.

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Chondrichthyans have experienced increasingly intensive fishing and habitat degradation pressure over recent decades. It is estimated that over-fishing has resulted in the loss of over 90% of sharks and large predatory fishes across all ocean basins. In the Northeastern Pacific, oceanic islands have been identified as aggregation sites for various shark species, leading to the creation of many marine protected areas such as the Galapagos, the Revillagigedo, Cocos and Clipperton Islands. Even though shark movements have been observed between these areas, suggesting connectivity among populations, little is known about the spatial ecology of the local shark species, compromising the ability to effectively manage their populations. In this context, the trophic ecology of four large shark species (the Tiger shark *Galeocerdo cuvier*, the Galapagos shark *Carcharhinus galapagensis*, the Silvertip shark *Carcharhinus albimarginatus* and the Silky shark *Carcharhinus falciformis*) was investigated in two different areas: the Revillagigedo Archipelago and Clipperton Island.

A multi-tracer approach combining stable isotope analysis (SIA), fatty acid (FA) composition, and FA compound-specific stable isotope analysis (FA-CSIA) was used. The trophic tracers showed different signatures between the two areas, suggesting site fidelity for these species, which are nevertheless able to realize long-distance migrations. For sharks from a same area, overlap was observed based on SIA and FA composition, highlighting trophic competition between top-predator species within these oceanic habitats. Finally, FA-CSIA allowed determining the likely source of fatty acids, revealing the ability for some individuals to forage on a wide range of habitats. The present study thus brought important results concerning the use of protected marine areas by shark species, which is critical for developing effective conservation measures for these threatened species.

QD486LD

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Latitudinal variation of the trophic niche of puye *Galaxias maculatus* (Jenyns, 1842) in river systems in southern Chile (36 ° - 47 ° S)

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Understanding of structure and flow of energy within river systems is essential for informed management of these systems and conservation of native fish fauna and fisheries resources. The complexity, habitat and abundance of food resources used by riverine fish, will depend on organic matter, the connection with terrestrial sources, riparian forests, floodplains as well as anthropogenic sources. In this study, we assessed the spatial variability in the trophic niche of *Galaxias maculatus* (Jenyns, 1842), based both on stable isotopes (carbon and nitrogen), and stomach content analyses along ten basins in a wide latitudinal range in Chile (37°S - 47°S). Our results show that estuarine populations in northern rivers presented smaller isotopic niche space in $\delta^{13}\text{C}$ - $\delta^{15}\text{N}$, feeding on the low diversity of prey. These isotopic niche spaces were significantly larger in fish from estuaries in southern rivers, mostly due to variation in $\delta^{15}\text{N}$ signals. Fish collected in lakes were characterized by small isotopic niche space, feeding mostly on zooplankton, with exception of the most southern basins, Aysén and Baker, in which the fish had significantly broader niche spaces mostly related to more variable $\delta^{13}\text{C}$ signals. Fish in main stems of more northern rivers with predictable flow regimes showed the most diverse diets, with high proportion of terrestrial items and zooplankton in their diet. This shows a greater variability in $\delta^{13}\text{C}$ sources and therefore significantly wider niche spaces compared to fish from lakes and estuaries. Our results suggest that the diet of puye in Chilean large river systems is strongly regulated by their flow regimes. Connectivity with floodplain habitats and supply from headwater lakes appeared to be the primary drivers of fish diet in systems where these are present. Therefore, maintaining seasonal flow dynamics and connectivity is essential to preserve the natural function of these river systems and conserve native fish populations.

RM758FP

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Invasive juvenile salmon affect the diet of native puye *Galaxias maculatus* in Patagonian fjords

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Chile has a long history of salmonid introductions for sport fishing and more recently salmon farming. Both activities have had a strong impact on freshwater ecosystems and have contributed to the colonization of ecosystems by introduced species such as brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). The ecological impact of these species has been widely studied in continental freshwater ecosystems. There are, however, no studies of their impact in southern Patagonian fjords. A recent study reported the presence of coho (*Oncorhynchus kisutch*) and chinook (*Oncorhynchus tshawytscha*) salmon juveniles in lakes draining into these fjords and in their respective outlet streams and estuaries. The presence of these species can diminish the food supply for native fish due to competition thus affecting their trophic niche, since the juvenile stages of coho salmon and chinook salmon were shown to feed on similar food items as native fish. The objective of this study was to evaluate the effect of presence of these salmonids on the trophic ecology of a native puye (*Galaxias maculatus*) in estuaries and lakes. Analyses were performed at two levels: stomach content analysis and isotopic niche analysis. Puye in two salmon-free lakes fed primarily on insects, whereas in the lake where it co-existed with coho salmon, puye seemed to mainly consume benthos. In estuaries, the diet of puye and salmon (coho and chinook) were similar. Furthermore, isotopic niche space of puye based on proportions of stable isotopes of carbon, nitrogen and sulphur in a lake where it co-existed with coho salmon was larger, compared to its niche in salmonid-free lakes. This larger niche space might be an effect of migrations of puye between the estuarine and freshwater habitats. Finally, in estuaries, niche spaces were similar between puye and coho salmon. The niche space was greater for chinook salmon compared to puye and coho salmon, most probably as an effect of their territorial behaviour and larger home range.

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TR463RP

Isotope ecology from individuals to communities A

Poster presentation Monday 30 July 2018

Origin of fish biomass in a diverse food web of a large subtropical river: increasing allochthonic biomass following flood pulses

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The origin of energy that supports fish biomass in large rivers has long been a subject of debate. Although, the River Wave Concept (RWC) integrates several theories and postulates that the energetic basis of food webs varies along its spatial-temporal location with respect to river geomorphological conditions and flow pulses, studies testing this theory are scarce, particularly those from large subtropical rivers. To analyse the origin of fish biomass in areas with differing geomorphological characteristics, we combined stable isotope analysis (carbon and nitrogen stable isotopes) with standardized measurements of biomass of a diverse fish assemblage along lower Río Uruguay. Furthermore, using 12 years of fish monitoring data, we tested for relationships between biomass of dominant allochthonous-derived species and river flow. Fish biomass was dominantly allochthonous-derived along the studied sites of lower Río Uruguay. Nevertheless, autochthonous-derived biomass was greater upstream, where the river is narrower and dominated by coarse substrates. Allochthonous C₃ plant-derived biomass prevails in the largest bay sampled where sediments bear the highest terrestrial organic matter accrual. Biomass generated from suspended particulate organic matter increased towards downstream reaching its maximum in the widest river section downstream. Moreover, the dominant species that derived most of its biomass from allochthonous resources (*Prochilodus lineatus*) increased its biomass with increasing river level, following flood pulses. This study supports the heterotrophic nature of food webs in large (sub) tropical rivers and the predictions made by RWC that local river geomorphology affects fuelling sources for food webs and that the allochthonous fraction of biomass increase following flood pulses.

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QL659CF

Plant isotope ecology

Poster presentation Monday 30 July 2018

Influence of climatic parameters on stable isotopes in scots pines in Potsdam, Germany

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The analysis of the stable isotope proportions in the organic matter of trees, allows to expand the knowledge about how the environment or the variability of environmental factors affect its incorporation into the tree. On the other hand, because the isotopic variations present, in many cases, a greater sensitivity to climate than those expressed by the tree ring width, the stable carbon and oxygen isotope compositions have been widely suggested as potential climatic proxies, mainly for temperature and precipitation.

This work deals with the influence of air temperature, precipitation, sunshine duration, cloud cover, and PDSI and SPEI indices, in the $^{13}\text{C}/^{12}\text{C}$ ratio ($\delta^{13}\text{C}$) and $^{18}\text{O}/^{16}\text{O}$ ratio ($\delta^{18}\text{O}$) in Scots pine (*Pinus sylvestris* L.) tree rings. The sampled pines were located on the Telegrafenberg, Potsdam, in northeastern Germany at an altitude of 94 m.a.s.l. For the analyses, 26 pines were sampled in August 2010 and a chronology was performed considering 58 cores. Four suitable pines were selected for the isotope analyses. The ratio of stable carbon isotopes and oxygen isotopes of each tree ring were measured between 1835 and 2009 using a mass spectrometer. Then, the $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ series were correlated with climatic variables using the CLIMTREG program. Climatic data were extracted from a nearby weather station covering the period between 1893 and 2009. The results showed that the $\delta^{13}\text{C}$ tree ring values were most strongly influenced by sunshine duration between May and September ($r = 0.744$). This strong correlation during spring and summer, may be associated with an increase in temperature associated with the duration of sunshine, which produces greater stomatal closure, thus decreasing ^{13}C discrimination and consequently increasing the $^{13}\text{C}/^{12}\text{C}$ ratio. Total daily precipitation presented the greatest influence on the $\delta^{18}\text{O}$ tree ring values ($r = 0.577$), which can be attributed to the sandy soil, that creates a high sensitivity of the pines to precipitation events due to the low possibility of water storage in the soil. It can be concluded that, in consideration of external and internal factors, stable carbon isotopes are most influenced by the sun and stable oxygen isotopes by precipitation.

JH622SL

Soil isotope ecology

Poster presentation Monday 30 July 2018

Impacts of nitrogen deposition on forest biogeochemical processes measured in new pools, across a trans-European gradient, investigated using a tool kit of stable isotope methods.

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Meta-data analyses and the model based hypotheses state that global soil C storage is controlled by microbial scale processes of fungal competition for available nitrogen (N). Global trends of increasing atmospheric N deposition and the continuing use of inorganic N fertilizer in both agriculture and forestry mean that the soils vital function as a carbon sink is potentially under threat. We set out to experimentally investigate these hypotheses across a Trans-European gradient of forest soils. Changes in soil nutrient status could result in a chain reaction of interacting microbial mechanisms which in turn could lead to the shifts in underlying ecosystem biogeochemical process rates. However, these changes are difficult to detect in the field in forest soils rich in organic carbon and nitrogen. We set out to determine whether we could identify functionally relevant pools to study the turnover of both nitrogen and carbon using stable isotope labelling.

We conducted experiments in which studied process rates and set up a series of dual isotope labelled C and N in-growth pine needle and beech litter bags have been incubating in-situ in the forest. The treatment plots have received additional inputs of inorganic nitrogen fertilizer over an eight-year period. We have studied both nitrogen and carbon dynamics in these systems using a tool box of stable isotope techniques. We observed a slight decline in the ¹³C signature of bulk soil in the labelled in-growth bags in both treatments, implying slow turnover and loss of the carbon litter added. Bulk soil pool analysis proved fairly insensitive.

To tease out the dominant processes further specific isotopic analysis of more constrained soil C and N pools have been conducted: respired CO₂, microbial nitrogen and carbon, inorganic nitrogen, extracellular polymeric substances and permanganate oxidizable carbon. These have proved promising fractions in which to trace the impact of nitrogen deposition.

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POSTER ABSTRACTS
Poster session 2
Tuesday 31 July 2018

CP249NF

Biogeochemical cycles and global change

Poster presentation Tuesday 31 July 2018

A 50,000 year $\delta^{15}\text{N}$ record of past variations in climate and nitrogen cycling from the Atacama Desert: terrestrial or marine sources?

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Terrestrial long-term records of N isotopes during the last deglaciation are very few and these often show large magnitude changes in $\delta^{15}\text{N}$ values. Present and past links between biogeochemical cycles and climate are fundamental to understand the functioning of the earth system. We present a $\delta^{15}\text{N}$ record from ^{14}C -dated fossil middens collected in the Atacama Desert to reconstruct the long-term dynamics of the regional N cycle over the last 50,000 years. During the last glacial period $\delta^{15}\text{N}$ values are often ~ 20 ‰ higher compared to present values after which $\delta^{15}\text{N}$ values began to oscillate between extreme positive and negative values (7 – 24 ‰) when regional temperatures began to increase. Interglacial $\delta^{15}\text{N}$ values are lower (around 10 ‰) and less variable than the previous period. $\delta^{15}\text{N}$ values increased with precipitation in the lower Atacama Desert. Hence, changes in $\delta^{15}\text{N}$ over the last 17,000 years in general appear to be related to precipitation which affects plant productivity and soil microbial activity. We showed that the %extralocal flora (a proxy for rainfall) correlated with $\delta^{15}\text{N}$ (middens with high %extralocal exhibit elevated $\delta^{15}\text{N}$ values). Yet, this did not explain the large 8 ‰ shift at 17-16 ka BP or the extremely high values seen in full glacial middens. Our midden $\delta^{15}\text{N}$ record was inversely correlated with a marine sediment $\delta^{15}\text{N}$ record off coastal northern Chile, a record that also revealed a large shift towards positive $\delta^{15}\text{N}$ values at 17 ka. This shift was coeval with the onset of ocean stratification and the development of an intense oxygen minimum zone. Long-distance nitrogen transport and fertilization of terrestrial ecosystems by marine N ventilation could in part explain the large N shift seen in our fossil middens as oxygen minimum zones began releasing large quantities of N_2O , a gas whose production increases at low levels of O_2 by denitrification and/or nitrification. Our record is likely a mixture of marine and terrestrial sources and processes. Major changes observed during the glacial-interglacial transition could be due to marine fertilization whereas the changes during the current interglacial are mostly a response of the terrestrial N cycling and regional climate change.

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Dynamics of particulate organic matter composition in coastal systems: forcing of the spatio-temporal variability at multi-systems scale

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Particulate organic matter (POM) is deeply involved in biogeochemical cycles and constitutes the base of food webs. In coastal systems, POM is a composite pool fuelled by autochthonous and allochthonous sources of pelagic, benthic and continental origin, and whose relative contributions highly vary over time and space. Twelve systems (three littoral systems, eight embayments and semi-enclosed systems, and one estuary) distributed along the three maritime façades of France were studied during one to eight years in order to quantify the relative contribution of organic matter sources to the surface-water POM and to assess the drivers of their spatial and temporal variability. At multi-system scale, two main gradients of POC composition have been identified: a 'Continent-Ocean' gradient associated to hydrodynamics, sedimentary hydrodynamics and depth of the water column, and a gradient of trophic status related to nutrient availability. At local scale, seasonality of POC composition appears to be station-specific but still related to part of the above-mentioned forcings. A typology of systems was established by coupling spatial and temporal variability of POC composition. Four groups were highlighted: 1) the estuarine stations where POC composition is dominated by terrestrial POM and driven by the hydrodynamics and sedimentary hydrodynamics, 2) the oligotroph systems, characterized by the contribution of diazotrophs due to low nutrient availability, and the marine meso/eutroph systems whose POC composition is 3) either deeply dominated by phytoplankton or 4) dominated by phytoplankton but where the contribution of continental and benthic POC is not negligible and is driven by the hydrodynamics, the sedimentary hydrodynamics and the height of the water column.

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Biogeochemical cycles and global change

Poster presentation Tuesday 31 July 2018

Assessment of leaf $\delta^{15}\text{N}$ and N concentrations as indicators of nitrogen dynamics in subtropical mangroves

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Increasing nitrogen (N) input is a key driver of global change with potentially large consequences for the conservation of natural ecosystems and the societal goods and services they provide. Mangrove ecosystems play a relevant role in N cycling at the terrestrial-aquatic interface in tropical and subtropical coastal areas worldwide. However, although excess N input have large consequences on N cycling in mangroves, and to the critical societal goods and services these ecosystems provide, our capacity to readily assess and monitor N cycling in mangrove ecosystems remains limited. Our main goal was to evaluate the applicability of leaf $\delta^{15}\text{N}$ and N concentrations as indicators of N dynamics in mangrove ecosystems for monitoring purposes. Once a year from 2015 to 2017, we evaluated N concentrations in leaves and sediment at 0-10 cm depth, and leaf $\delta^{15}\text{N}$ at 18 permanent study plots of fringe mangrove forests differing in species dominance, stage of ecological succession, and structural development along a N pollution gradient under a humid subtropical climate in the Estuarine-Lagunar Complex of Cananeia-Iguape (UNESCO World Heritage and Ramsar sites) in southeastern Brazil. Concentrations of nitrate in sediment were lower at highly N-enriched mangroves, with median (1st and 3rd quartiles) values of 0.07 (0.05 and 0.11) mg/kg, than less and non-N-enriched mangroves, 0.20 (0.12 e 0.24) mg/kg. While leaf N concentrations and C:N and N:P ratios were mostly similar among study sites, leaf $\delta^{15}\text{N}$ was significantly higher at N-enriched, 5.5 (4.7 and 6.2) ‰ than non-N-enriched mangroves, 4.7 (4.3 and 5.2) ‰. Despite a large variability on vegetation structure and conservation status, leaf $\delta^{15}\text{N}$ was a consistent indicator of alterations in N dynamics following N pollution in mangrove ecosystems. The information obtained in the present study may provide subsidies for the proper management of the study area. The methodology employed in our study may also be useful for monitoring N dynamics in other tropical and subtropical coastal systems.

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Biogeochemical cycles and global change

Poster presentation Tuesday 31 July 2018

Terrestrial contributions to the marine food web from pluvial watershed in the northeast Pacific Temperate Coastal Rainforest domain

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Coastal temperate rainforests (CTRs) - such as those found along the coasts of northwest North America, Patagonia, and southwest New Zealand - are hotspots for linked ecosystem processes because of the tight connections between terrestrial and marine ecosystems driven by substantial materials fluxes across coastal margins. Terrestrial-marine linkages are shaped by unique combinations of physical and biogeochemical properties, including steep terrain, high precipitation and runoff from the landscape, enormous stores of above- and below-ground organic carbon and nutrients, and extensive and complex shorelines. The northeastern Pacific coastal temperate rainforest (NPCTR) exemplifies this type of coastal margin hotspot, stretching across a vast archipelago from southeast Alaska to the coast to northern California. The NPCTR is globally recognized as one of the most carbon-dense forested areas, the largest contiguous expanse of CTR, and the least impacted, largest remaining old-growth temperate rainforest. To date most research on terrestrial contributions to marine food webs have focussed on glacial systems, ignoring the rain dominated (pluvial) watersheds that make up ~ 50% of the annual discharge to the PCTR. Recent studies in British Columbia (Canada) have demonstrated these systems to yield some of the highest dissolved organic carbon (DOC) loads recorded globally. Between 2013 and 2016 the Hakai Institute implemented a long term study of pluvial watershed outputs and uptake by the coastal marine food web. Bulk stable isotopes of dissolved and particulate organic matter, and zooplankton size fractions were measured at high temporal resolution over the seasonal cycle in the coastal ocean adjacent to eight watersheds. A pronounced seasonal cycle was observed of marine dominated organic matter contribution to the plankton food web during the dry summer months and, conversely, terrestrial dominated organic matter contributions during the wet winter months. We further report on the application of amino acid specific carbon isotope measurements to tracing food web pathways in the NPCTR and the implications for the fate of terrestrial carbon in the coastal ocean.

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Biogeochemical cycles and global change

Poster presentation Tuesday 31 July 2018

Hydro-geochemical water inputs identification in glacialized basin hydrology

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Economies in developing countries strongly rely on natural commodities, generating anthropic pressures over hydrological resources. Although glaciers do not occupy a large area of these mountain ranges, they deliver vital water for downstream populations. This is especially relevant during drought periods, when winter precipitation is strongly diminished and ice-melt becomes relevant. They are also a key resource for highland wetlands ecosystems and for society development. Regularly, for environmental impact assessments and relevant public consultations, it will be stated that water from glaciers does not constitute an important source within the basin system, even though this has not been accurately quantified. Different water sources, given by spatial, geological and hydrological features, can be identified using a combination of ionic and isotopic information from water. Thus, allowing to establish their proportions downstream, where water from different origins is mixed, and also to track their evolution over seasons. This approach should be useful especially for basins with strong pressures for the exploitation and consumption of water in mountainous basins, with special relevance for basins with little or no knowledge of their water system and reservoirs.

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Biogeochemical cycles and global change

Poster presentation Tuesday 31 July 2018

Vertical and temporal variation in the concentration of stable isotopes of nitrogen during upwelling events, in front of Punta Ángeles, Valparaíso.

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The coastal system of central Chile is subject to upwelling driven by south and south-west winds which change the vertical structure of the water column fertilizing surface waters with nutrients that enhance primary productivity, generating specific Particulate Organic Matter ¹⁵N signatures (¹⁵N-POM). Moreover, the upwelled water is characterized by low-oxygen and high-nutrient associated with the subsurface oxygen minimum zone (OMZ), potentially enriched in ¹⁵N inorganic nitrogen (nitrate and nitrite) due to anaerobic nitrogen loss processes (e.g., denitrification and annamox). Thus, the fertilization by upwelling in the surface layer enhances primary productivity with a different fractionation of the stable isotopes of nitrogen respect of system without OMZ. In this study, the temporal and vertical variability of the oceanographic and biogeochemical variables (dissolved oxygen, nutrients, N₂O, stable isotopes in the MOP) were analyzed, with a focus on the changes in the ¹⁵N-POM along the water column during two years considering periods with and without coastal upwelling events in the Valparaíso Oceanographic Time Series (STOV), a monthly time series conducted between January 2015 and October 2016 off Punta Ángeles, Valparaíso. Ekman wind, stress and surface transport data were also analyzed to determine the upwelling periods.

The results show that the ¹⁵N-POM mean values 3.7, 1.73, and 3.09, at the mixing layer, oxycline and OMZ, respectively. This variability was associated with a well-defined seasonal oceanographic variability caused by coastal upwelling during the spring-summer period, having significant differences only at the first two layers ($p < 0.02$), associated with an impoverishing of ¹⁵N-POM signal during the periods with coastal upwelling. While for the OMZ there were no significant differences in the isotopic signal in months with and without coastal upwelling ($p > 0.1$).

NJ737JL

Biogeochemical cycles and global change

Poster presentation Tuesday 31 July 2018

Hydrocarbon production by marine cyanobacteria in the open ocean: a precursor for the Oceans' ability to naturally recover from oil input

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Prochlorococcus and *Synechococcus* are the two most abundant marine cyanobacteria, contributing to a quarter of the global marine net primary production. Considering the wide distribution of *Synechococcus* in temperate coastal waters and the open ocean, as well as the domination by *Prochlorococcus* in the oligotrophic ocean, these cyanobacteria are important players in ocean ecosystems. It is known that cyanobacteria synthesize long chain hydrocarbons from fatty acids in laboratory cultures. In the ocean, the production of these hydrocarbons may sustain a population of hydrocarbon-degrading bacteria, notably, in regions with minimal inputs from natural oil seepage. These biogenic hydrocarbons may play a key role in sustaining populations of hydrocarbon-degrading bacteria in the oligotrophic ocean, thus priming the microbial community to respond to anthropogenic oil inputs. Here, I present research from a cruise aboard the *R/V Neil Armstrong*, measuring cyanobacterial hydrocarbons in the oligotrophic ocean, which naturally occur at ng/L concentrations. Production estimates at several stations were made using stable C-13 enrichment incubations. Several depth distributions were quantified, revealing a tight proportional relationship of nC15 to fluorescence in the oligotrophic gyre, and a defined change in the suite of biogenic hydrocarbons when moving from eutrophic to oligotrophic waters; both important relationships for future modeling of global marine hydrocarbon flux. Production estimates from C-13 enrichment in the oligotrophic gyre reveal that the highest nC15 production rates are at low illumination [1% of normal light level]; low illumination waters also showed the fastest degradation rates of all depths, suggesting that flux is large and tightly coupled here. Results from sinking particles, depth profiles, and degradation rates at low light, are all in agreement that there is a rapid degradation of hydrocarbons at and immediately below the 1% light level (~90 to 150m in the oligotrophic ocean)-suggesting that this region may be key in seeding hydrocarbon degrading communities to degrade oil. Further investigation should be taken to test if low-light waters serve to inoculate the surface ocean with a sufficient hydrocarbon degrading community in the face of new oil input.

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Changes in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ by biological invasion in subtropical mangroves, Brazil

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Mangroves occur at the interface between terrestrial, freshwater and marine systems playing a number of important ecosystem functions linked to carbon (C) and nitrogen (N) cycling. The magnitude of human activities is one of the main drivers of global environmental changes and has favored the increase of biological invasions in these ecosystems. Biological invasions have the potential to largely affect C and N cycling in natural ecosystems and the ecosystem functions they provide. The construction of a canal connecting the Ribeira de Iguape River to the northern zone in the Estuarine-Lagunar Complex of Cananeia-Iguape (ELC-CI), southeastern Brazil, caused a deviation of about 60% of the original course flow into the estuary. The increased freshwater input was responsible for the reduction of salinity and massive invasion by aquatic macrophytes in the mangrove. Our objective was to evaluate the aquatic macrophyte invasion impacts on the C and N dynamics in mangroves in the ELC-CI. We collected native mangrove vegetation and invasive species leaves to analyze C and N concentrations and $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$. We sampled 18 study plots of conserved and invaded fringe mangrove forests. Leaf C:N ratios were about two times lower in invasive aquatic macrophytes than in mangroves species. Invasive aquatic macrophytes had higher $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ than mangroves species. The leaf $\delta^{13}\text{C}$ of mangroves indicated the predominance of C3 photosynthetic pathway whereas the leaf $\delta^{13}\text{C}$ of aquatic macrophytes indicate a mixture of C3 and C4 sources. The dominant invasive aquatic macrophytes in the study plots included *Urochloa arrecta* and species of the genera *Scirpus* that have a C4 photosynthetic pathway. We predict that the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ of the organic matter from the invaded mangrove sediments will present higher values of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ compared to the conserved mangroves, due to the mixture of differential C3 and C4 organic matter sources and higher intensity of decomposition, respectively. Invasive aquatic macrophytes seem to intensify C and N dynamics by introducing organic matter of lower C:N ratios into the sediment, which should favor both C and N gases losses to atmosphere while reducing C and N storage in mangrove ecosystems.

This study was supported by the Conselho Nacional de Desenvolvimento Científico e Tecnológico CNPq – Brazil (Processes 445418/2014-1), the Fundação Grupo O Boticário (Process BL0006_2012_1), and by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior CAPES - Brazil.

SQ853TR

Celebrating the contribution of Brian Fry to Isotope Ecology

Poster presentation Tuesday 31 July 2018

Individual diet specialization in a community of granivorous small mammals living in a stochastic environment

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Interest in individual diet specialization (IS) has promoted creative research on both the ecological and evolutionary causes of this significant source of variation in natural populations. Most empirical-based studies on IS have focused on single taxa and the effects of intraspecific competition. Comparatively few studies have examined temporal variation in IS and the effect of interspecific competition within communities that inhabit stochastic environments characterized by seasonal and inter-annual variation in the quantity and quality of resources. We used a mixed C₃–C₄ shrubland–grassland in the Chihuahuan Desert to examine how seasonal variation in resource availability over two consecutive years influenced IS within a community of four closely-related granivorous small mammal species. We focused our analysis on spring net primary production (NPP) that is dominated by high quality C₃ plants, which have larger seeds with higher nitrogen contents than seeds produced by C₄ grasses. We used blood plasma $\delta^{13}\text{C}$ data from ~130 individuals across four species from which we collected >3 (monthly) samples within the spring season to compare the effects of inter-annual variation in NPP on population isotopic niche width (TINW) and IS. TINW and the prevalence of IS, as measured by the ratio of the within-individual component (WIC) of diet to TINW, varied in relation to inter-annual availability in spring NPP. In a relatively productive (2014) spring, TINW was low for all species, and 3 of the 4 species had high degrees of IS (WIC/TINW: 0.35–0.50). During the following (2015) spring when NPP was exceptionally low, all species expanded their TINW but had lower levels of IS (WIC/TINW: 0.75–0.88), indicating a high degree of dietary generalism at both the individual and population level. Contrary to predictions, inter-specific competition had no consistent impact on IS. Our results suggest that when preferred resources become scarce, individuals of all species broaden their dietary niche, which ultimately expands the TINW. Overall, our study suggests that the prevalence of IS is fluid in this stochastic environment, even over short (seasonal) timescales.

CD631QJ

Isoscapes and movement ecology

Poster presentation Tuesday 31 July 2018

The distribution of $\delta^{13}\text{C}$ in the Central Brazilian Savanna and its historical occupation process

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The conversion of the native vegetation of the Brazilian Neotropical Savanna, known locally as Cerrado, was intensified between 1960 and 1970, and the predominant land use in the region is cultivated pasture. Cerrado shrub tree vegetation has C_3 photosynthetic cycle, while most of the species used in agricultural activities present a C_4 photosynthetic cycle. Some recent studies address the spatial variability of isotopic values on maps, what has been called Isoscapes. The aim of this work was to present a $\delta^{13}\text{C}$ interpolation model in the Cerrado soil at three depths (0-20, 20-40 and 40-60 cm) and compare them with the distribution patterns of areas for Cultivated Pastures, Annual Agriculture and Natural Vegetation, according to the TerraClass Cerrado project land cover mapping. For this, we use data of 55 points with isotopic values widely distributed in the Cerrado. These data were interpolated by inverse distance. We found a latitudinal distribution pattern of the $\delta^{13}\text{C}$ values for the natural areas which are a mixture between C_3 and C_4 plants where the highest values were concentrated in the southern region of the Cerrado while the highest soil $\delta^{13}\text{C}$ in all depths were observed in the southeast and southwest regions of the Cerrado which are dominated by cultivated C_4 pastures. In agricultural areas, the values of $\delta^{13}\text{C}$ alternated between a wide range from C_3 to C_4 which can be explained due to the mixture between the most common annual cultures (C_3 soybean and C_4 maize), where crop rotation technologies are widely used. This pattern may be related to the historical process of occupation of the Cerrado, where, the southern regions have been converted to pastures over 50 years evidencing the C_4 signal in the soil profile even some of the areas have been later converted to agricultural areas. On the other hand in the central and north regions which have been converted more recently are still holding a mixture of the $\delta^{13}\text{C}$ values due to the conversion of some of the areas directly from native to agricultural areas with different C_3 and C_4 plant rotation managements.

Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES)

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Isoscapes and movement ecology

Poster presentation Tuesday 31 July 2018

Where do seabirds moult over winter? - A combined data logger and isoscape assignment approach

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Many pelagic seabirds moult their feathers while at sea, which is an energetically costly behaviour. Mortality rates during moult can be high, so spatial and trophic ecology during this critical period is important for understanding demographic patterns. Unfortunately, individual foraging behaviours specifically linked to at-sea moult are commonly unclear. We have combined two independent, but indirect approaches to geolocation: data from bird-borne geolocation loggers and stable-isotope assignment using carbon and nitrogen North Sea isoscapes. Coupling two geolocation processes allows some uncertainties associated with isotope-based assignment to be constrained. We applied this approach to quantify species-specific foraging locations and individual trophic variability during feather regrowth in razorbill and Atlantic puffin populations breeding on the Isle of May, Scotland. We identify differences in foraging behaviour between the two species across two periods with strongly contrasting ecological conditions and seabird survival. During the feather moult period, puffins were found to forage in consistent locations in years with both high and low survival rates, but diet changed, with a lower trophic positions in winters with poor survival. By contrast, razorbills maintained trophic position but shifted foraging area between the two periods. In the winter with good survival, puffin and razorbill overlapped in foraging areas during feather moult, but razorbills showed a more southerly foraging location in the poor survival year. When considered with prey availability data, razorbills were suggested to have adopted the more successful foraging strategy, with reduced mortality rates than puffins during the poor survival year. Used in combination, light based and isotope-based geolocation methods better constrain foraging areas and provide a technique to explore individual trophic differences and flexibility in foraging strategy. With future environmental conditions and prey availability set to vary, research into the ability of different seabird populations to adapt their foraging behaviours is essential for effective spatial based management.

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Isoscapes and movement ecology

Poster presentation Tuesday 31 July 2018

Can we detect changes in Arctic ecosystems? (ARISE) - An isoscape of the Arctic Regions

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Due to unprecedented rates of environmental change, the Arctic is now a crucible of multiple concurrent stressors. Understanding how food webs are being reshaped over different spatial and temporal scales in response to these stressors is crucial in addressing the impacts of future change on biodiversity and ecosystem services. Stable isotopes of nitrogen (^{14}N , ^{15}N) and carbon (^{12}C , ^{13}C) are efficient tools to highlight changes in trophic position of predators and food chain length. But, the isotopic signal recorded at each trophic level is sensitive to the ^{15}N and ^{13}C at the base of the food web, termed the 'isoscape'. A well constrained isoscape baseline is therefore crucial to understand potential changes measured "at the top of the food web". Stable nitrogen isotopes of amino acids (i.e. $\delta^{15}\text{N-AA}$) is a novel approach that overcomes this problem. Indeed, the $\delta^{15}\text{N}$ of "source" amino acids (e.g. phenylalanine) indirectly fingerprints the base of the food web as it conservatively traces the $\delta^{15}\text{N}$ of primary producers. Moreover 'trophic' amino acids (e.g. glutamic acid) are enriched during trophic transfer and so isolate a predator's trophic position. Particulate organic matter (POM) makes up the bulk of the isoscape and is itself underpinned by primary producers, whose $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values are controlled by bottom-up factors, specifically (a) the $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ of the dissolved nutrient and carbon sources, (b) the magnitude of N and C sources and (c) isotopic fractionation during assimilation of N and C by phytoplankton. All these are likely to vary in response to environmental change in the Arctic. Here we present a spatially resolved isoscape from our first field campaign to the Barents Sea during summer 2017 as part of the ARISE project. We analysed water column profiles of POM for both bulk Carbon and Nitrogen stable isotope and Nitrogen stable isotope of amino acids data. We combined these results with literature data to create a robust spatial and temporal isoscape of POM across the arctic regions.

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Isoscapes and movement ecology

Poster presentation Tuesday 31 July 2018

A marine top predator shows expected $\delta^{15}\text{N}$ but unexpected $\delta^{13}\text{C}$ values along a latitudinal gradient

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Spatiotemporal variation in stable isotope ratios, commonly denominated as isoscapes, are increasingly being used in science as they provide key information for hydrological, ecological, archaeological and forensic studies. Stable isotopes, especially those of carbon and nitrogen, have been at the forefront of the development of spatial markers in studies of feeding zones, movement patterns and migration routes of numerous species. Analyses of isoscapes based on $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ have usually been performed using values from the base of the food web. However, few accessible reference maps of the isoscapes are available for marine predators. The South American sea lion (SASL, *Otaria flavescens*) is a good model to analyze potential isoscapes of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$, since this species is found along the entire coast of Chile, and its diet composition strongly depends upon the local abundance of prey. The objective of this study was to analyze the values of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in tissues of the SASL along a 2,700km latitudinal gradient in the Chilean coast. From 2009 to 2015, skin samples were collected from 617 adult SASL individuals in 12 localities between 18.6 and 42.5 °S. SASL showed significant variation in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values over their latitudinal range. There was a positive and significant relationship between $\delta^{13}\text{C}$ values and latitude. In contrast, a negative relationship was found between $\delta^{15}\text{N}$ values and latitude. This variation may be used as a first approximation to the construction of isoscape maps in the Chilean coast, and as a form to better understand habitat use and migration and foraging behavior of pelagic marine species such as migratory fish, turtles, birds and mammals. Also, the isoscapes emerged from this study may serve as a base to understand how the different processes of fractioning, biological transformations and the dynamics of these nutrients in the water column operate along the Chilean coast.

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Area: Isoscapes and movement ecology

Poster presentation Tuesday 31 July 2018

A zooplankton $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isoscape of San Jorge Gulf, Argentina: the potential for tracking movement and habitat use of top predators over small spatial scales.

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Isoscapes of (baseline) $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values at the base of food webs provide useful gradients to track animal movements, especially for highly mobile marine top predators that move large distances during their annual life cycle. Besides, quantifying sources of variation in baseline values is necessary to estimate and compare trophic levels and bento-pelagic reliance among species from different sites. In pelagic marine ecosystems, a variety of physicochemical factors influence the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ of phytoplankton at the base of the food web. Growth rate is one of the primary factors influencing $\delta^{13}\text{C}$, while $\delta^{15}\text{N}$ is influenced by (1) the extent of vertical mixing of the water column that regulates the source and amount of nitrogen available for primary production, and (2) the degree of recycling of nitrogen. Here we reconstruct a $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ zooplankton isoscape for the San Jorge Gulf (40 000 km²) off the southern Patagonian coast of Argentina, a unique ecological hotspot for seabirds and marine mammals that also supports a lucrative prawn fishery (50 000 tons.y⁻¹). In this region, high productivity depends in two oceanographic fronts at the southern and northern margins of the gulf. Isoscapes were reconstructed using zooplankton sized between 200–300µm collected from a regular grid of stations in November of 2016; a series of physical (e.g., temperature, salinity, density) and chemical (e.g., nitrate, phosphate, silicic acid) variables were also measured at each station. Zooplankton $\delta^{13}\text{C}$ values varied between -24.7‰ and -17.5‰. Lower $\delta^{13}\text{C}$ values were observed in the center of the gulf where waters are more strongly stratified, while the northern and the southern margins of the gulf where greater mixing occurs had higher $\delta^{13}\text{C}$ values. $\delta^{15}\text{N}$ values varied between 5.6‰ and 13.5‰ and generally increased from south to north, which closely correlates with the input of nutrients from deep cold waters along the southern margin and higher rates of nutrient recycling along the northern front. These baseline gradients occur over relatively small scales (200–300 km), and may enable the tracking of movement and habitat use of the diverse community of top predators in this region.

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Isoscapes and movement ecology

Poster presentation Tuesday 31 July 2018

Geographical assignment using $\delta^{18}\text{O}$ of turquoise-fronted parrot along the southwest-wetland to the Central savanna region in Brazil

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Water related stable isotopes ($\delta^{18}\text{O}$ and δD) have been widely used for geographical assignment of migrant birds and in forensic cases around the world. Despite some studies use $\delta^{18}\text{O}$ to assign migrant birds to its origins in South America, no study has used animal tissue ground validated isotope data to test precipitation data correlation or tissue-to-tissue isotope conversion in this region. We chose as a model the turquoise-fronted parrot (*Amazona aestiva*) because it is a resident species, widely distributed along the southwest-wetland region (Pantanal) to the savanna region (Cerrado) in Central Brazil, and it is one of the most trafficked birds in Brazil. Those characteristics coupled to tissue $\delta^{18}\text{O}$ would ultimately help to assign seized birds to be re-introduced in nature. We present $\delta^{18}\text{O}$ data from newborn parrot blood and feathers collected both in Pantanal and in the core area of Cerrado in Central Brazil. We also used data from precipitation isotopic ratios provided by the Global Network for Isotopes in Precipitation (GNIP) to correlate with $\delta^{18}\text{O}$ from parrots' tissues. We found spatial correlation and positive correlation with predicted $\delta^{18}\text{O}$ from precipitation. The tissue-to-tissue conversion was about 1‰ between blood and feathers from same individuals. There was about 7‰ difference between those parrots sampled in the Pantanal and Central Brazil. Tissue-to-tissue conversion is similar to previous findings for birds and its small value should not restrain both tissues use in same model, as geographical isotopic differences seems to be higher. As supposedly many trafficked birds come from wetlands, these findings will be useful to confirm this assumption on real cases or to suggest alternative sources of illegally collected birds in Brazil. Results confirm GNIP isotope data correlation and will be used to create a bird specific isoscape and an assignment model for all wetland and savanna regions of Brazil.

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Isoscapes and movement ecology

Poster presentation Tuesday 31 July 2018

Testing the utility of isotopes in feces for noninvasively studying the spatial ecology of big cats

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We know surprisingly little about the spatial ecology of carnivores in the wild. This is particularly true for elusive, solitary species, like jaguars (*Panthera onca*). Fecal isotopic analysis may complement other non-invasive monitoring tools like grids of motion-detecting cameras and genetic scat sampling. The isotopic composition of feces is dominated by the most recent meal and should reflect the habitat and geology where prey lived and were killed and consumed. We used the novel combination of carbon ($\delta^{13}\text{C}$), nitrogen ($\delta^{15}\text{N}$), and strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) isotopes in fecal matter to investigate if it is possible to detect movement of jaguars across a geologically- and biologically-varied landscape.

Our sample included 24 jaguar scats collected with the help of a scat-detection dog in summer 2007 from the Mountain Pine Ridge Forest Reserve (MPR) in Belize, Central America. The vegetation is lowland and submontane pine forest in northwest and central MPR. Broadleaf forest is found in western MPR and along the eastern edge of the reserve. The primary geologies are Silurian granite in northwest MPR, Late Paleozoic clay-rich sediments in southern and eastern MPR. Mesozoic carbonates and contact metamorphics also outcrop in western and central MPR, respectively. Scats were genetically assigned to four males ('Jaguar 1', 'Jaguar 2', 'Jaguar 3', 'Jaguar 5') and one unknown individual. Atomic C:N are comparable for relatively fresh versus older scats (C:N for all samples ranges from 4.2-6.8). We found considerable isotopic variability among scats, particularly in central MPR. Ranges are -24.6 to -20.0 ‰ for carbon, 7.2-14.9 ‰ for nitrogen, and 0.71526-0.74753 for strontium. Overall, C, N, and Sr isotopes tend to be higher for scats from northwest MPR and lower in eastern MPR. Isotope data suggest that jaguars 1 and 2 regularly forage within south-central and north-central MPR, respectively. Jaguar 3 may forage in eastern MPR and surrounding protected areas dominated by broadleaf forest. Jaguar 5 and the unidentified individual (each represented by one scat) may regularly forage in northwest and southeast MPR. We conclude that fecal isotope analysis complements existing non-invasive monitoring tools by providing spatial information that is not captured by other methods.

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Area: Isoscapes and movement ecology

Poster presentation Tuesday 31 July 2018

Using an agent-based movement model to test different drivers which lead to the $\delta^{13}\text{C}$ tissue values of a seabird

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Biologgers have revolutionised our understanding of the foraging ecology and life history traits of marine predators, providing high resolution information about location, and in some cases, foraging behaviour. At the same time, stable isotope ecologists have independently developed methods to infer location and foraging ecology (trophic geography). To date, relatively few studies have combined these two approaches, despite the potential wealth of complimentary information. In marine systems, spatial and trophic information are coded in the isotopic composition of carbon and nitrogen in animal tissues, but interpretation of isotope values is limited by both the lack of reference maps (isoscapes) needed to relate the isotopic composition of an animal's tissues to a location, and the relatively large number of variables that could influence tissue isotope compositions. Simulation modelling can help to interpret measured tissue isotope compositions of migratory animals in the context of spatio-temporally dynamic isotopic baselines. Here, we couple individual based movement models to global marine isotope models to interpret isotopic data recovered from biollogger-equipped female northern giant petrels *Macronectes halli* incubating eggs on sub-Antarctic Marion Island. Eighteen individual birds were tracked with GPS loggers and as they returned from the logged foraging trip, a blood plasma sample was taken for stable isotope analyses. We use *in silico* experiments to simulate isotopic compositions expected for birds conducting a range of different movement and foraging behaviours and compare simulated and measured data. We show how the *in-silico* experiments enhance interpretations both of geolocation and foraging behaviour, particularly improving retrospective geolocation from intrinsic biochemical tags (e.g. $\delta^{13}\text{C}$). This method is a powerful tool that can be applied to any mobile marine predator, and we believe that the *in-silico* modelling approach outlined here will stimulate more studies combining biollogger and intrinsic biochemical methods for geolocation.

- South African National Antarctic Programme

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Isoscapes and movement ecology
Poster presentation Tuesday 31 July 2018

A UK/Ireland insect isoscape

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Migration in insects is widespread. Linking locations used by individuals is crucial to understand their ecology, to conserve threatened species and to understand how climate change may change their distribution and numbers. Much has been learned from radar studies, mark-recapture and tagging, however stable isotopes offer an alternative approach since they are intrinsic markers and thus every insect captured and measured reveals information about location. This project aims to measure the isotopic composition of H, C, N and S in the tissue of a resident moth to see whether the resulting isoscape can be used to distinguish migrants from residents in the UK and Ireland. Isoscapes were based on wing ($\delta^2\text{H}$) and head ($\delta^{15}\text{N}$, $\delta^{13}\text{C}$ and $\delta^{34}\text{S}$) tissues of the oligophagous widely-distributed brimstone moth (*Opisthograptis luteolata*).

Evenly-distributed citizen scientists were asked to collect up to three specimens scattered over the flight season. Around 300 samples from 95 locations were analysed for all four isotope ratios; at one location 28 samples were collected over the entire flight season to assess temporal isotope variation. I discuss spatial and seasonal isotopic variation and consider what environmental factors determine the isoscapes. Are the results what one might expect, given spatial variation of isotopes in precipitation ($\delta^2\text{H}$), proximity of oceanic sulphate aerosols ($\delta^{34}\text{S}$), and a fairly uniform diet of deciduous leaves ($\delta^{13}\text{C}$)? Finally, I discuss the potential for this isoscape differentiating migrant from resident insect species and ultimately for assigning location.

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Isoscapes and movement ecology

Poster presentation Tuesday 31 July 2018

Baseline isoscapes for the western Andean region (18°-22°S)

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Environmental stable isotopes have been widely used to trace biogeochemical cycles, water-use, pollution, natural vs anthropogenic climate change forcing and biological/human migrations. Isotope landscape explicit models (hereafter isoscapes) have gained popularity for the analysis, application and interpretation of these data in addressing geological, ecological and social patterns and processes. In practice, isoscapes provide a mechanistic framework for visualizing and predicting changes in isotope concentrations at different spatio-temporal scales. Hence, isoscapes are friendly-user maps that depict isotope variability driven by geographical variations in Earth's system process. Such models require cross-disciplinary networks to monitor and gather dense data for environmental relevant isotopes on diverse array of landscape matrices over large geographic regions. Here, we present preliminary results for an exhaustive characterization of distributions, trends and co-variations in ¹³C, ¹⁵N, ¹⁸O, ²H, and ⁸⁷Sr/⁸⁶Sr at small and large spatial scales along the western Andean slope between 18°-22°S -an area of diversified climate, topographic, hydrological, geological and ecological conditions-. This study represents the first effort in South America for delineating specific isoscapes for stable isotopes commonly used in natural and social sciences, that have involved six latitudinal-altitudinal transects to collect vegetation, fauna, air (N₂O), sediments and water resources across main relief units, hydrological and bioclimate units from northernmost Chile.

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Area: Isotope ecology from individuals to communities B

Poster presentation Tuesday 31 July 2018

Isotopic changes in the euphausiid *Stylocheiron* sp. in the eastern South Pacific

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The euphausiids are one of the most abundant mesozooplanktonic crustacean groups in the global ocean. They are distributed from tropical to polar regions. They are recognized as a key component in the food web of marine pelagic ecosystems because of their importance to transfer energy from primary producers to upper levels. The objective of this study was to evaluate the spatial variation of the euphausiid community structure along a transect (Caldera - Easter Island) in the Eastern South Pacific. Samples of zooplankton were collected on the CIMAR 21 cruise onboard the RV Cabo de Hornos, using two Tucker Trawl nets (mouth area: 8 m² and 1 m², mesh: 300 μm). The oceanographic conditions were characterized by a CTDO. The euphausiids were found in comparable abundances in both coastal and oceanic areas (including surrounding Easter Island). Results show differences in the composition of species along the longitudinal gradient. The dominant genus in the coastal zone was *Euphausia* sp. and in the oceanic waters it was *Stylocheiron* sp. This difference suggests a differential adaptation in relation to the oceanographic conditions that dominate each zone. Due to this hypothesis, the isotopic signal in the *Stylocheiron* sp. was evaluated to observe differences in the carbon source ($\delta^{13}\text{C}$) and trophic position ($\delta^{15}\text{N}$). The length of the individuals decreased from coastal to oceanic regions. *Stylocheiron* sp. trophic position decreased from regions closer to the continent towards oligotrophic regions. This could be because of the smaller phytoplankton dominating the oligotrophic zone. The $\delta^{13}\text{C}$ differences confirmed carbon sources between these two ecosystems, which could be reflecting differences in primary productivity and/or a different diet for the coastal species of the oceanic ones. Also, isotopic variability was observed in two stations near Easter Island which could be due to the location of them; one on the north side of the island and the other one in the south.

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Area: Isotope ecology from individuals to communities B

Poster presentation Tuesday 31 July 2018

The dark side of soft tissue: non-expected inorganic carbonates in the invasive slipper limpet *Crepidula fornicata* and implications for stable isotope interpretations

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Stable isotope (SI) analysis is widely used in trophic ecology. It is generally agreed that some taxa (*e.g.* Molluscs) don't need acid pre-treatment since their shell represents the only source of inorganic carbonates. However, other sources of non-dietary carbon enriched in ¹³C can considerably skew SIA results. Soft tissue samples of *Crepidula fornicata*, an invasive and hermaphroditic species commonly used in trophic ecology studies were analysed for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ with and without acid pre-treatment. The origin of the obtained isotopic deviations was investigated using alizarin red, a dye used to detect carbonates in histology. We provided evidences that acid pre-treatment have a significant impact on SI ratio of *Crepidula fornicata* foot tissue. The isotopic difference increases with individual size, reaching up to 2‰ for largest females. No effect was detected for males, which sizes remain inferior to 25 mm. Histological staining showed the presence of numerous small spherules of inorganic carbonates, explaining the differences of $\delta^{13}\text{C}$ ratio. Then, we applied a correction model on published SI data obtained for *C. fornicata* to estimate the risk of error when inferring trophic role of potential food sources and inter-specific competition level with mixing model. Results showed that untreated samples can lead to misinterpretation regarding the competitive status of *C. fornicata*. We strongly recommend checking for the presence of inorganic carbonates in soft tissue of sessile (*e.g.* *Crepidula fornicata*) or low motile (*e.g.* *Calyptrea chinensis*) gastropods inhabiting on calcareous substrates, especially when interpreting their stable isotopes ratios together with those of a large set of species. Rapid and simple tests such as using red alizarin staining can be performed without any specific histological skills. This additional but easy-doing step may avoid serious misinterpretations with stable isotope data.

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Isotope ecology from individuals to communities B

Poster presentation Tuesday 31 July 2018

Geographic variation in trophic position and the contribution of basal resources fuelling loco *Concholepas concholepas*, a Chilean keystone gastropod.

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The loco *Concholepas concholepas*, a carnivorous benthic gastropod, is considered a keystone predator in Chilean rocky-shore systems. They are heavily over-exploited, yet little is known about their basic ecology, limiting our capacity to conserve this economically and functionally-important species. Here we examined loco trophic ecology and their role in N Chilean coastal food webs using analysis of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$, and fatty acids from three different regions along a 1000km S-N latitudinal gradient: Coquimbo (29°S), Antofagasta (23°S) and Iquique (20°S). Loco $\delta^{15}\text{N}$ values were increasingly ^{15}N -enriched to the north, indicating a possible shift in trophic position. However, $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values in filter-feeding bivalves and grazing gastropods also varied along the S-N gradient. As such, we calculated loco trophic position (TP) and the relative contribution of pelagic-derived C and N to their diet (α), using tRophicPosition, a recently developed Bayesian model. A two-baseline tRophicPosition model showed that loco TP varied significantly along the S-N gradient: TP was highest in Coquimbo (median TP (5–95 % credibility interval) = 3.3 (3.0–3.6)), intermediate in Antofagasta (2.7 (2.5–3.0)) and lowest in Iquique (2.6 (2.4–2.8)). TP values <3 indicate that locos are either not strictly carnivorous or assimilate materials from the gut of their animal prey. Although benthivorous, α estimates indicated that locos consumed prey feeding almost entirely on pelagic-derived C and N in Coquimbo ($\alpha=0.94$ (0.79–1.00)) and Antofagasta (0.98 (0.90–1.00)). Locos from Iquique were dominated by pelagic-derived C and N, but to a lower level (0.75 (0.55–0.98)), suggesting that they also consumed prey fuelled by benthic-derived materials, e.g. macroalgae or biofilm. FA profiles supported these results, which showed a high percentage of pelagic biomarkers including C20:5(n-3) and C22:6(n-3). However, loco FA profiles varied significantly between regions. A discriminant analysis (CAP) using the SIA and FAA values of locos allowed them to be grouped to capture location with 80% classification success. This clearly reflects spatial differences in oceanographic conditions (e.g. upwelling intensity) which drive variation in isotopic baselines, but we also show here that trophic function of locos also varies regionally, which needs to be considered in any conservation actions

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Isotope ecology from individuals to communities B

Poster presentation Tuesday 31 July 2018

Aspects of trophic ecology of odontocetes species from Uruguay

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Marine mammals are generally key species attributed to its predation in almost all trophic levels, therefore changes in their abundance and distribution could affect the structure and function of ecosystems. Along the coast of Uruguay a total of 40 species of marine mammals have been recorded, 32 belong to the order Cetartiodactyla which are in turn divided between the suborders Odontoceti (22 spp) and Mysticeti (10 spp). Despite this, the information on the trophic ecology of these top predators remains scarce in Uruguay. The aim of this work is to evaluate resource partitioning in three species of the suborder Odontoceti occurring in Uruguayan waters: *Tursiops truncatus*, *Pseudorca crassidens* and *Delphinus delphis*. In order to examine trophic relationships and compare isotopic niche space among species, carbon and nitrogen stable isotopes ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) in collagen are analyzed. For this propose specimens held in national collections in the coasts of Uruguay between the years 1947 and 2016 were sampled. The knowledge about trophic relationships and the degree of trophic overlap between these predators allows us to understand the mechanisms through which they can coexist, moreover is important for understanding the ecological roles of these animals in the food webs.

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Isotope ecology from individuals to communities B

Poster presentation Tuesday 31 July 2018

The isotopic niche overlap and segregation of two snappers (Pisces: Lutjanidae) in a tropical seascape of mangroves and coral reefs.

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Lutjanidae are reef fishes that represent one of the most important trophic compartments connecting estuarine mangroves and marine reefs, since some species use such ecosystems along their life stages. In this work we investigated the trophic overlap between two snappers: *Lutjanus analis* and *L. alexandrei* collected in a Mangrove-Reef continuum located inside an environmental protected area of Northeast Brazilian Coast (Tamandaré, PE). We analyzed muscle tissues for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ stable isotopes (EA-IRMS) from 33 individuals collected during 2017 austral summer. We used Bayesian ellipses and Layman's metrics (SIBER, ranges, CD and MNND) to assess the trophic overlap and isotopic niche breadth by comparing the individuals caught in Mangrove versus Reef. As a general pattern we found that specimens from Mangrove showed ^{13}C depleted $\delta^{13}\text{C}$ values (-25.0 to -21.4‰) in relation to individuals from Reefs (-20.3 to -10.9‰) showing no $\delta^{13}\text{C}$ overlap inter-sites. All the metrics (ranges, TA, CD and MNND) were higher for Reef, indicating a wide niche and diversification of resource use for both species in reefs. The niche overlap intra site revealed that in Mangrove habitat there was isotopic overlap on the use of resources and apparently also on the trophic level. *Lutjanus alexandrei* $\delta^{13}\text{C}$ range was very low (1.4‰ of variation), indicating a narrow trophic niche. No niche overlap was observed between species at reef, mostly driven by $\delta^{15}\text{N}$ average difference (1.8‰), which could indicate segregation along the food chain of almost one entire trophic level. These results showed that while these species share the same resources as juveniles and sub-adults in mangroves, trophic segregation occurs just when they move into the marine area and occupy reef habitats. Inclusion of more individuals as well as to incorporate food sources and baselines could help to evaluate in a finer scale the resource use and trophic position along this environmental continuum.

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GP321PC

Isotope ecology from individuals to communities B

Poster presentation Tuesday 31 July 2018

"Chicken-eating" foxes: isotopic evidence of individual specialisation in a rural population of red fox

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Abundance and distribution of food resources directly influence adaptative strategies in foraging which in turn are strongly related to individual fitness and population demography. Specialisation toward food resources is commonly observed in predator species, both at population and individual levels. When predation occurs for food products derived from humans or agriculture, human-wildlife conflicts rise and call for efficient management of problematic species. In Bresse (eastern France), free-ranging poultry farms annually suffer from important losses due to predation from several bird and mammal species, including red foxes (*Vulpes vulpes*). Here, we quantified the diet of the red fox, and investigated dietary specialisation on chicken using stable isotope analysis. Vibrissae of 68 foxes were cut into fragments to measure inter- and intra-individual variability of diet, allowing us to reconstruct foxes diet on an average of 134 days. At the population level, over 70% of the diet was composed of rodents and chickens. Within the population, we found contrasting carbon isotope compositions, indicating that some foxes preferentially consumed prey with high $\delta^{13}\text{C}$ values, such as Bresse chickens fed with maize, while others consumed wild food resources. We estimated that 4.4% of the fox population was composed of ultra-specialists towards chicken predation. Chicken predation was higher in females than males and occurred more often in summer, when females are rearing cubs. The high availability of an easily catchable food resource could explain why some red foxes use this ecological opportunity in their diet definition. This result calls for peculiar adapted management strategies toward specialised foxes.

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GP893MB

Isotope ecology from individuals to communities B

Poster presentation Tuesday 31 July 2018

Isotope niche of active soil insects as a proxy of vegetation structural complexity in neotropical savanna landscapes

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The Central Brazilian savannas (Cerrado) is composed by a vegetative mosaic of grasslands (predominant C_4 -plants with sparse C_3 -plants), savannas (mix of C_3 and C_4 -plants) and forests (predominant C_3 -plants) interspersed in the landscape. The Cerrado landscapes have changed considerably over the last four decades due land use changes, imposing diverse effects to plant and animal communities. To improve our knowledge about land use change effects we need to go beyond species diversity analysis and also understand the species niche width in natural and modified habitats and landscapes. Here we analyzed ants and beetles (very representative and active insects in Cerrado soils surface) to investigate the range of resources accessed by these groups in natural and modified landscapes in Central Brazil. We sampled insects with pitfall traps in four riparian forests, four native savannas and four native grasslands but also at three savanna patches surrounded by cultivated pastures (predominant African C_4 -grasses). Using $\delta^{13}C$ and $\delta^{15}N$ of most representative ants and beetles of each vegetation cover, we evaluated the isotopic niche in SIAR/SIBER using the: (i) $\delta^{15}N$ -range, (ii) $\delta^{13}C$ -range, (iii) corrected standard ellipses (SEAc), which measure the isotopic niche width; and (iv) standard deviation of nearest neighbour distance (SDNND) which evaluate trophic niche evenness. Beetles presented lower $\delta^{15}N$ -range (except native savanna beetles) and higher $\delta^{13}C$ -range (except savanna patches beetles) than ants. For ants, the highest niche width was found in riparian forests and the lowest niche evenness was found in savanna patches. For beetles, the highest niche width was found in native savannas and the lowest niche evenness in savanna patches. These results indicate that those soil surface beetles belong to a similar trophic level and explore a greater range of resources than ants, which on the other hand belong to different trophic levels. The $\delta^{13}C$ values of forests and pastures beetles indicate that these insects explore the surrounding vegetation. In savanna patches, both beetles and ants presented low niche width and great niche evenness. These results highlight the potential use of insect isotopic niche as an important tool to evaluate patterns of dispersion and consumer-resource interaction in natural and modified neotropical savanna landscapes.

Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)

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Isotope ecology from individuals to communities B

Poster presentation Tuesday 31 July 2018

Trophic plasticity of scleractinian corals under contrasted environmental conditions: evidence from stable isotope analysis

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Most scleractinian corals can derive nutrition either autotrophically or heterotrophically, which allows them to use diverse trophic pathways. Therefore, when facing environmental changes, these organisms are expected to demonstrate an intrinsic ability to acclimatise through trophic plasticity. Despite the ecological importance of these corals, our understanding of their trophic plasticity is currently impaired by a lack of rigorous research approaches; a failure to take into account the intraspecific variability of coral species and an oversimplification of the proxies of heterotrophic habits (e.g. corallite diameter). In order to understand how trophic plasticity could allow them to acclimatise, this study proposed to assess the trophic plasticity of three morphologically contrasted coral species (*Stylophora pistillata*, *Porites* sp and *Tubastraea coccinea*). We determined the stable isotope ratios of carbon and nitrogen in the coral host tissues and algal symbionts (when present) and compared these in corals inhabiting areas around Taiwan characterised by contrasted temperature (from high to low latitudes) and light levels (from shallow to mesophotic waters). For each area, we evaluated intraspecific and interspecific trophic variability by estimating and comparing coral trophic positions and trophic niches. Our results provide essential insights into the trophic plasticity of scleractinian corals and how these species might adjust their nutrition in response to environmental changes.

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HD264PD

Isotope ecology from individuals to communities B

Poster presentation Tuesday 31 July 2018

A global perspective on the trophic geography of sharks

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Stable carbon and nitrogen isotopes in animal tissues vary largely due to the composition and spatial origin of the diet, revealing the trophic geography of consumers. Sharks are a diverse group of mobile predators that forage across varied spatial scales and have the potential to shape or stabilise food webs. Recent declines in shark biomass may have broader ecological consequences if sharks display common behavioural traits across taxa and regions. We used mechanistic isotope models to track the original site of photosynthetic fixation of carbon atoms ultimately assimilated into muscle tissues of 5394 sharks from 114 species. We then identify globally consistent biogeographic traits in trophic interactions between sharks found in different habitats. We show that populations of shelf-dwelling sharks derive a substantial proportion of their carbon from regional pelagic sources, but contain individuals that forage within additional isotopically-diverse local food webs, such as those supported by terrestrial plant sources, benthic production and macrophytes. By contrast, oceanic sharks appear to use carbon derived from between 30 and 50 degrees of latitude. Global-scale compilations of stable isotope data combined with biogeochemical modelling can generate novel hypotheses regarding animal behaviours that can be tested with additional methodological approaches.

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Isotope ecology from individuals to communities B

Poster presentation Tuesday 31 July 2018

Comparison of the trophic ecology between the shortfin mako *Isurus oxyrinchus* and the blue shark *Prionace glauca*, in Southeastern Pacific waters

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Sharks have several biological characteristics that do not permit them to recover quickly from fisheries overexploitation, e.g. through bycatch of longline fisheries for swordfish (*Xiphias gladius*). We sampled stomach contents and analysed stable isotopic ratios from shortfin makos *Isurus oxyrinchus* and blue sharks *Prionace glauca*, in Southeastern Pacific waters captured as bycatch over 5 months during 2015. This was conducted to allow a comparison of diet and other ecological aspects of both shark species with the aim to gain an understanding of the role they play in the oceanic ecosystem. Both have a similar dietary hierarchy, but with differences in trophic level ($P < 0.05$) and trophic niche. This may reflect several factors including prey availability, impacts of fisheries or changes in the environment in which these species feed.

JS218MS

Isotope ecology from individuals to communities B

Poster presentation Tuesday 31 July 2018

Trophic niche and habitat use of two sympatric endemic dolphin species from Patagonia, Argentina

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Dolphin species that lives in sympatry frequently requires some degree of resources partitioning, differing in diet and habitat use patterns as a strategy for coexistence. In the southwestern Atlantic Ocean, Commerson's and Peale's dolphins use different habitats both inshore and offshore, such as open ocean, rivers mouths, deep bays and kelp forests. Stomach content analysis suggests that both species feed mainly on pelagic and demersal fish and cephalopods. While most preys are shared they differ in the principal prey items. In order to understand the trophic relationships between these species, the aim of this study is to determinate the trophic niche and habitat use of two endemic dolphins that lives in sympatry along the Argentine Sea. Stable carbon and nitrogen isotope ratios were analysed of 14 and 23 skin biopsies of Commerson's and Peale's dolphins, respectively, sampled in December 2007 to 2009 in southern Chubut, Argentina (45° 04' 34.5''S, 65° 38' 37.2''W). Significant differences in both $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ were found between species. In particular, Peale's dolphins showed two ecotypes segregated in habitat. $\delta^{13}\text{C}$ difference suggested the spatial partitioning in depth or distance from shore inter and intraspecific, being the Commerson's dolphins and Peale's dolphins ecotype1 more pelagic/offshore and the Peales dolphin ecotype2 more benthic/inshore. Isotopic niche width varied between species and ecotypes. Commerson's dolphins presented lower inter-individual variation ($\text{SEAc}=0.28\text{‰}^2$), following by ecotype1 ($\text{SEAc}=0.39\text{‰}^2$) and ecotype2 ($\text{SEAc}=1.31\text{‰}^2$) of Peale's dolphins. The results indicated a partitioned use of resources between these two small cetacean species living in sympatry. Moreover, the Peale's dolphins seem to have two different foraging strategies in a small area promoting the coexistence and reducing intra/inter specific competition. To our knowledge, this is the first study characterizing the trophic niche and habitat use of Peale's and Commerson's dolphins living in sympatry along the Patagonia, Argentina.

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Isotope ecology from individuals to communities B

Poster presentation Tuesday 31 July 2018

Towards a global, freely available database of stable isotope ratios in foundation species from deep-sea hydrothermal vents and cold seeps

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In the absence of light, communities associated to deep-sea hydrothermal vents and cold seeps strongly rely on habitat and food resources provided by chemosynthetic symbiont-bearing foundation species. However, due to the lack of adapted studies encompassing the vast heterogeneity of seeps and vents environments, factors globally influencing trophic ecology of those animals are still unclear. To tackle this issue, we are currently setting up a large-scale compilation of stable isotope ratios of C, N and S in bivalve molluscs and siboglinid worms from deep-sea vents and seeps. The data acquisition strategy is based on 1) analysis of available literature and 2) new valorisation of specimens already sampled during past cruises. The compiled database will be used to understand, through global, large-scale analysis, how environmental and biological factors (sampling location, depth, fluid composition and emission intensity, substrate nature, presence of other foundation species, etc.) can drive ecology of foundation species. In doing so, we hope to generate new insights about the ecology of these organisms that, despite their critical importance for deep-sea ecosystems, are still poorly known. Moreover, we aim to provide the deep-sea and stable isotope communities with a freely available data analysis tool that can be used in the context of future ecological research. In deep-sea vents and seeps, stable isotope ratios of symbiont-bearing invertebrates can indeed be used to indirectly estimate the isotopic baseline of food webs, in an analogous way as suspension feeders are used in coastal marine ecosystems. By making our database accessible online through the IsoBank repository (www.isobank.org), we will therefore help deep-sea researchers to use stable isotope markers at their full efficiency.

To maximise the scope of the database, we are currently looking for new partners that would be willing to contribute to the project by sharing suitable data or samples. If you match this description, or are in contact with people that do, please get in touch during the IsoEcol 2018 conference.

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MT398FT

Isotope ecology from individuals to communities B

Poster presentation Tuesday 31 July 2018

Trophic relationships in a seabird assemblage associated with fisheries at the Patagonian Continental Shelf.

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Overlap in diets and intra- and interspecific competition for food might influence the evolution of species and communities. This is also predicted for seabirds and so, seabird species within a community are expected to have distinct trophic niches. However, the interaction with fisheries and the potential exploitation of discards and/or fishery waste provides an alternative scenario that could be quite distinct from natural sources of food. Here we compared the trophic niche of a seabird assemblage associated with fisheries operating in the Patagonian Continental Shelf. We measured carbon and nitrogen stable isotopes in whole blood ($n=72$) and pectoral muscle ($n=12$) of seabirds from the offshore wintering community of Procellariiformes. Samples of *Thalassarche melanophrys* (BBA), *Procellaria aequinoctialis* (WChP), *Daption capense* (CP), *Ardenna gravis* (GSH), *A. grisea* (SSH) and *Oceanites oceanicus* (WSP) were obtained from birds captured onboard vessels or from bycaught birds during winter 2011-2013. Stable Isotope Bayesian Ellipses in R (SIBER) was used to compute the area of the Bayesian ellipses and the overlap of the isotopic niches. Overall isotopic differences were observed (Pseudo $F_{5,78} = 28.4$, $P < 0.001$), mainly due to larger values in WChP and BBA compared to other species. Narrower isotopic niches were observed for BBA ($SEA_B = 0.96\text{‰}^2$, $CrI = 0.7-1.32\text{‰}^2$) and WChP ($SEA_B = 0.83\text{‰}^2$, $CrI = 0.32-2.35\text{‰}^2$) with large overlap between them (0.63‰^2). GSH also showed narrow isotopic niche ($SEA_B = 1.15\text{‰}^2$, $CrI = 0.50-2.41\text{‰}^2$) but no overlap was observed with other species except to its congener. Wider niches observed in both SSH ($SEA_B = 5.4\text{‰}^2$) and CP ($SEA_B = 4\text{‰}^2$) is probably reflecting a variable use of different waters masses (*i.e.* from Antarctic to subtropical areas). BBA and WChP both feed by surface seizing but have different diving capacity. Moreover, diet composition of these two species is known to differ as well as the water masses explored at the Continental Shelf. Our results show both species consuming prey from similar trophic level and associated to waters from the Patagonian Continental Shelf. These overlap in isotopic niche could be, at least in part, a product of the exploitation of feeding resources facilitated by the fishery industry.

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Microbial isotope ecology

Poster presentation Tuesday 31 July 2018

Potential dissemination of microorganisms by invertebrates: is the trophic activity of Collembola responsible for microbial stain dissemination in Lascaux Cave (SW France)?

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The Lascaux cave located in South-West of France is well known for the numerous parietal paintings and engravings covering its walls. Because of its archeological interest, the Lascaux cave was heavily visited until 1963, when the cave was closed to public access due to microbial developments on wall paintings. A series of microbial crises occurred in the last five decades, and microbial outgrowths were removed by mechanical cleaning and chemical treatments. Black stains were noticed on cave walls in 2006 and are still present despite treatments. Fauna survey and direct observations in the cave revealed that black stains harbor populations of *Folsomia candida* (Collembola). The objective of this work was to determine if *Folsomia candida* could feed on the black stains and therefore disseminate the microorganisms responsible for black stain development through their trophic activity. *Folsomia candida* individuals were reared at the laboratory under controlled conditions and in the presence of black stain shreds sampled by curators in the Lascaux cave, or of different fungus and bacteria strains isolated from the black stains. Dissemination was demonstrated by displacing each individual on sterile culture medium in petri dishes and subsequent monitoring of microbial developments. Assimilation of black stains, isolated fungus and bacterial strains was quantified using ¹³C-labeling and measurements of ¹³C/¹²C ratio of Collembola and their potential food source during the experimentations. Since direct labelling of substrates from Lascaux cave was not possible, Collembola were labeled using ¹³C before the experimentations, and substrates were kept at natural ¹³C/¹²C ratio. The significant decrease of the $\delta^{13}\text{C}$ of Collembola during the course of the experiments demonstrated efficient feeding of *Folsomia candida* on black stains and indicated that the dissemination of microbial stains along Lascaux cave walls can be enhanced by the trophic activities of Collembola.

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Using POM stable isotope values to characterise upwelling effects on variation of coastal microbial communities.

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The composition of microbial communities is increasingly being used to characterise environmental variation across a range of habitats, with a growing recognition of the role of microbes in driving many fundamental ecological and biogeochemical processes. In a similar way, stable isotope analysis (SIA) of environmental samples has provided information on ecosystem function and how it varies over space and time.

Here, we use stable isotope values of C and N of particulate organic matter (POM) along a 1.000 km latitudinal gradient (20°S to 29°S) as an indicator of coastal upwelling intensity and associate its impacts on the structure of nearshore microbial communities, assessed through next-generation sequencing. During Austral Summer and Winter 2013, water samples were collected from 16 sub-sites close to rocky reef or kelp forest habitats for sequencing of the 16S rRNA gene via Illumina platform and for the analysis of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in POM.

There was a clear and significant effect of both Location and Season on the microbial community composition (PERMANOVA $P = 0.0001$ for both Factors), and POM $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values (PERMANOVA $P < 0.002$ for both Factors). It was also observed a clear latitudinal gradient in POM $\delta^{15}\text{N}$, and POM was ^{15}N enriched in Summer, the period of more intense upwelling. There was a strong relationship between microbial community composition and POM $\delta^{15}\text{N}$ recorded at a given site and time (CAP canonical correlation = 0.79, $P = 0.0001$).

Our findings show that coastal microbial communities vary significantly both spatially and temporally. It is likely that a major driver of change in microbial community composition is coastal upwelling, giving the strong correlation between a proxy for upwelling (POM $\delta^{15}\text{N}$) and microbial community composition. The lack of variation found in $\delta^{13}\text{C}$ is indicative that the differences in microbial community structure were not driven by differences in phytoplankton productivity itself.

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New methods and models in isotope ecology

Poster presentation Tuesday 31 July 2018

Characterizing energy flow in nearshore ecosystems using amino acid $\delta^{13}\text{C}$ analysis

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Ecological investigations require an understanding of energy movement through food webs and the relative importance of different sources of primary production to consumers. Stable isotope analysis of bulk tissues containing a mixture of macromolecules has been heavily utilized in this regard, however, these studies are limited by substantial overlap among producer isotope values coupled with sorting (discrimination) of isotopes as organic material moves from the base to the top of food chains. Carbon isotope ($\delta^{13}\text{C}$) analysis of essential amino acids (AA_{ESS}) has recently been shown to offer better resolution in tracing energy flow. However, this approach has yet to be tested by studying local food webs. Here, we used AA_{ESS} $\delta^{13}\text{C}$ analysis to examine community dynamics of two contrasting nearshore kelp-forest ecosystems, a downwelling zone in Alaska and a strong upwelling zone in Chile. We characterized AA_{ESS} $\delta^{13}\text{C}$ profiles for eight different producer taxa from both sites, including kelps, green algae, red algae, and offshore particulate organic matter (POM). We also sampled over 10 invertebrate and vertebrate consumer species spanning a range of trophic/functional groups. We used linear discriminant analysis (LDA) and isotope mixing models (MixSIAR) to test the ability of AA_{ESS} $\delta^{13}\text{C}$ to distinguish between producer groups, as well as to classify consumers according to their reliance on different producers. Results clearly showed the utility of the AA_{ESS} $\delta^{13}\text{C}$ approach and its potential in studies of coastal food webs. For Alaska, LDA showed good separation among producer taxa, with an 88% successful reclassification rate; however, we could not distinguish between POM and green algae (*Ulva*). For our Chilean site, LDA demonstrated exceptional separation among producer taxa, with better than 95% reclassification rate. At both sites, we also found substantial heterogeneity among consumers in terms of the energy pathway utilized. In Alaska, AA_{ESS} derived from green algae/POM was most important for lower trophic level invertebrates (e.g. *Mytilus*) whereas kelp was critical for upper trophic levels (e.g. *Pycnopodia*). In contrast, POM dominated the supply of AA_{ESS} to upper level vertebrate consumers in Chile. Overall, our results highlight the power of AA_{ESS} $\delta^{13}\text{C}$ analysis in tracing energy flow within complex marine ecosystems.

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Physiology and biochemistry
Poster presentation Tuesday 31 July 2018

Field metabolic rates of teleost fishes are recorded in otolith carbonate

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Field metabolic rate (FMR) is the rate at which energy is consumed by an organism operating within its habitat, including energetic costs associated with maintenance, food respiration and activity. As such, field metabolic rate is key to understanding individual- and population-level responses to environmental changes, with implications for climate change, population range shifts and global fishery potential. FMR is challenging to measure in organisms operating in natural environments, however, especially in aquatic animals. Here we show that in teleost fishes, FMR can be estimated from the isotopic composition of carbon in otolith aragonite. We report results from an experiment using Atlantic cod (*Gadus morhua*) living under laboratory conditions to describe the mechanistic relationship between carbon isotope compositions of otoliths and oxygen consumption rates. We then use our derived relationships to infer field metabolic rates in wild ranging cod and other fish species. The otolith isotope metabolic proxy offers a new approach to study physiological ecology in free ranging wild fishes. Otolith-based proxies for FMR are particularly promising as they allow retrospective assessment of time-integrated, individual-level field metabolic rate throughout an individual fish's life history.

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Physiology and biochemistry
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Effect of drought on grassland CO₂ efflux and its $\delta^{13}\text{CO}_2$

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CO₂ efflux and its isotope composition ($\delta^{13}\text{CO}_2$) from a mountain grassland ecosystem was measured over two growing seasons (2016 and 2017) on six plots. Three plots were exposed to ambient precipitation and three plots were covered with roofs inducing short or long-term drought in 2016 and 2017, respectively. CO₂ efflux was immediately reduced when the drought induced. After the short drought in 2016, CO₂ efflux returned back to the level of CO₂ efflux in plots with ambient precipitation. During the long-term drought in 2017, the differences in CO₂ efflux between dry and ambient variant gradually increased through the drought period. Drought resulted in CO₂ efflux ¹³C-enriched compared to that under ambient precipitation conditions. As well as CO₂ efflux, $\delta^{13}\text{CO}_2$ rapidly recovered after the short drought and remained higher through the whole long-term drought period. In both years, $\delta^{13}\text{CO}_2$ of CO₂ efflux from the grass was isotopically enriched compared to ecosystem CO₂ efflux. In 2016, $\delta^{13}\text{CO}_2$ of grass CO₂ efflux in the dry variant was higher compared to the ambient, while no differences were observed in 2017. The results might indicate that drought had bigger effect on soil than on grass CO₂ efflux and that autotrophic component of soil respiration is less sensitive to dry conditions compared to heterotrophic.

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Plant isotope ecology
Poster presentation Tuesday 31 July 2018

Towards the identification of past atmospheric conditions through a high-resolution $\delta^{13}\text{C}$ tree-ring record for the last 400 years in Patagonia

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The tree ring stable carbon isotope composition record for the last four century was examined to analyze the effects of the isotopically lighter CO_2 input in the atmosphere due to the fossil fuel burning mainly since the mid-nineteenth century. This process produced a decrease in the $^{13}\text{C}/^{12}\text{C}$ ratio of the atmosphere ($\delta^{13}\text{C}_{\text{atm}}$) while the CO_2 concentrations increased ($\text{CO}_{2,\text{atm}}$). Moreover, due to the atmospheric CO_2 is assimilated by trees through the photosynthesis process, $\delta^{13}\text{C}$ of trees ($\delta^{13}\text{C}_{\text{tree}}$) and $\delta^{13}\text{C}$ of atmosphere can be related. This work reported records of whole wood $\delta^{13}\text{C}$ from 1600 to 2000 obtained from tree rings of a number of cross-dated *Fitzroya cupressoides* trees from northwestern Patagonia. The $\delta^{13}\text{C}_{\text{tree}}$ series showed evidence of affinities with the $\delta^{13}\text{C}_{\text{atm}}$ as expressed by the couples $\delta^{13}\text{C}_{\text{atm}}-\delta^{13}\text{C}_{\text{tree}}$ and $\text{CO}_{2,\text{atm}}-\delta^{13}\text{C}_{\text{tree}}$. Comparisons were supported by a well-replicated and significant correlated $\delta^{13}\text{C}$ tree-ring values from NW Patagonia. Thus, the strong common variability in the $\delta^{13}\text{C}_{\text{tree}}$ values among individuals provided access to a good representation of the $\delta^{13}\text{C}_{\text{atm}}$ trends in the region. The 400-year $\delta^{13}\text{C}_{\text{tree}}$ curve showed regular fluctuations between 1600s and the beginning of 1800s and a long-term decline after 1840, being this decrease more pronounced during the last 50 years. The accelerated $\delta^{13}\text{C}_{\text{tree}}$ decrease after 1950 was particularly stronger from the 1970's to date. The similar variation pattern observed between our $\delta^{13}\text{C}_{\text{tree}}$ record and those from other regions of Earth suggests that trends in Patagonia are representative of the global $\delta^{13}\text{C}_{\text{atm}}$ variations. Moreover, global atmospheric CO_2 concentrations and $\delta^{13}\text{C}_{\text{atm}}$ values revealed to be strongly correlated with the tree-ring stable carbon isotopic composition. In this sense, results showed the potential of this record as indicator of the variations of these atmospheric variables over both the past and recent periods in the Southern Hemisphere.

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Plant isotope ecology

Poster presentation Tuesday 31 July 2018

How carnivorous are carnivorous plants? Investigating reliance on heterotrophy using natural abundance stable isotope techniques

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Plants are typically defined by their ability to synthesise their own food (autotrophy), and are usually positioned at the base of trophic webs. However, many plant species have developed heterotrophic nutritional strategies, in which they are fully or partially reliant upon other organisms for obtaining nutrition. Carnivorous plants are unique in that they are the only group of heterotrophic plants to employ specially modified leaves, rather than roots, to obtain mineral nutrition from other organisms. Perhaps one of the most fascinating aspects of carnivorous plants is their inversion of trophic webs. Based on the theory of isotopic enrichment, a carnivorous plant's position in a trophic web can be elucidated using natural abundance stable isotope methodology. Schulze et al (1991) were the first to apply these techniques to the study of carnivorous plant nutrition *in situ*, revealing a clear enrichment in $\delta^{15}\text{N}$ for carnivorous *Drosera* species in southwest Australia when compared to neighbouring autotrophic plants. As a whole, Western Australia is a global centre of carnivorous plant diversity, hosting over 150 *Drosera* species, over 50 *Utricularia* spp., eight *Byblis* spp., the endemic *Cephalotus follicularis*, and the rare aquatic carnivore *Aldrovanda vesiculosa*, spread over the Mediterranean southwest and the tropical northern Kimberley region. Despite this incredible diversity and the unique opportunity for comparative research on the carnivorous habit, there have been relatively few studies of the ecology and nutrition of carnivorous plants in Western Australia. We address this significant knowledge gap by applying natural abundance isotopic methodology to quantify reliance on heterotrophic nutrition for a range of carnivorous plant species found across Western Australia. This study provides empirical evidence for differences in heterotrophy amongst co-occurring carnivorous plant species in two contrasting climate types across a broad range of habitats. Questions of evolutionary biology and global ecology of carnivorous plants will be explored, and implications for conservation of carnivorous plant species will be examined.

Schulze, ED., Gebauer, G., Schulze, W. & Pate, JS. (1991): The utilisation of nitrogen from insect capture by different growth forms of *Drosera* from southwest Australia. *Oecologia* 87: 240-246

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Plant isotope ecology

Poster presentation Tuesday 31 July 2018

Variations in the intrinsic water-use efficiency of *Araucaria araucana* trees under a present climate change scenario: tree age and site conditions effects

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Stable isotopes are of great interest to conduct ecophysiological and paleoenvironmental researches. The analyses of the tree-ring $^{13}\text{C}/^{12}\text{C}$ ratios ($\delta^{13}\text{C}$) allow to study the environmental changes effects on tree development and water use over time. Thus, the $\delta^{13}\text{C}$ values allow to estimate the intrinsic water-use efficiency (iWUE) of trees. Moreover, the iWUE variations depend on local conditions, tree ontogeny or both. In this sense, the product of this study revealed the physiological responses of young and adult *Araucaria araucana* trees from two open xeric and two dense closed mesic forests to the atmospheric CO_2 concentrations (C_a) increase and climate changes during the 20th century in northern Argentine Patagonia. In each site, 4 young trees (≤ 214 years) and 4 adult trees (≥ 264 years) were sampled. The α -cellulose $\delta^{13}\text{C}$ contents of 5 tree-ring segments were analyzed. The results indicated that although an increase in the iWUE was shown by all trees during the last century in response to both changes in C_a and climate, tree responses strongly depend on ontogenetic, local and geographical characteristics. Trees from xeric sites presented greater iWUE and lower ^{13}C discrimination ($\Delta^{13}\text{C}$) and intercellular CO_2 concentration (C_i) values than the mesic ones. Moreover, iWUE and $\Delta^{13}\text{C}$ values from mesic sites seemed to be mainly affected by temperature and light conditions, while trees from xeric condition appeared to be more affected by other factors, as precipitation. In general, adult trees presented significantly higher iWUE values than young trees, indicating that processes related to tree age and/or height induce different responses, mainly in dense and closed forests. These greater iWUE values can be attributed to hydraulic limitations reducing stomatal conductance in taller trees, to changes in irradiance and photosynthetic capacity depending on the tree position in the stand structure, and to more drought conditions in the upper part of the canopy experienced by taller trees. Finally, given the heterogeneous responses of trees to climate and given the endangered status of the *A. araucana* forests, further studies are needed to better understand how these forests may be affected in their physiology in the present and future climate change scenarios.

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Plant isotope ecology

Poster presentation Tuesday 31 July 2018

Hidden robbery: A new multi-element stable isotope natural abundance approach discloses organic carbon-gain effectiveness of C₃-hemiparasites from C₃-host plants.

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Introduction: Carbon stable isotope data showed for a few 'xylem-feeding' C₃-hemiparasitic plants utilizing C₄- or CAM-hosts the usage of two different carbon sources, autotrophy and heterotrophy. This $\delta^{13}\text{C}$ approach, however, failed for the much more frequently occurring C₃-C₃ parasite-host-pairs. To overcome this obstacle, we used hydrogen stable isotope (^2H) natural abundances as substitute for ^{13}C within a C₃-Orobanchaceae-sequence graded by morphological features and C₃-Santalaceae. Material & Methods: Nine 'xylem-feeding' C₃-parasitic species ($n=97$) and fully autotrophic potential C₃-host plants ($n=289$) were collected in 2016 and 2017 in Central Europe at in total 12 sites. Samples were collected either once in the vegetation period, or along development-dependent time-series. A multi-element stable isotope natural abundance approach was realized by analysing $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, $\delta^2\text{H}$, $\delta^{18}\text{O}$ and element concentrations. Leaf dry weight measurements (LDW) were included to support the evaluation of development-dependent shifts in plants' heterotrophy. Hydrogen isotope abundance in plant tissues is counterbalanced by transpiration (^2H -depletion) and gain of host-derived organic matter (^2H -enrichment). The transpirational effect was subtracted out of the plant tissue $\delta^2\text{H}$ values through the plant tissue $\delta^{18}\text{O}$ values, which are mostly driven by the transpiration difference between parasite and host. Nutrient-gain efficiencies were calculated applying the two-source linear mixing model. The hemiparasites approach ($\delta^2\text{H}$) to one or the other side were assumed to represent the parasitic effectiveness. Results: A species-specific heterotrophic carbon-gain ranging from 10 to 70 % was calculated. The sequence in heterotrophic carbon-gain mostly met the sequence in root morphological features. Stable isotope patterns suggest a relative constant development-dependent heterotrophy for *Rhinanthus minor* (30~11 %). However, more specialised hemiparasites showed a development-dependent shift from heterotrophy (seedlings) towards autotrophy (adults) applying stable isotopes and LDW patterns. At later samplings, only the stem-parasite *Viscum album* seemed to become more heterotrophic. Conclusions: Due to higher transpiration and lower water-use efficiency depletion in $\delta^2\text{H}$, $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ compared to C₃-host plants should be expected for tissues of C₃-hemiparasites. However, stepwise enrichment in ^2H stable isotope is caused by the parasites' heterotrophic organic matter gain and can be used to estimate carbon-gains from hosts.

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Plant Ecology
Poster presentation Tuesday 31 July 2018

Presence of adjacent grasses enhances while $^{14}\text{NH}_4^+$ -addition to receiver-pines reduces ^{15}N -movement between paired-pine saplings

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Nutrient movement in common mycorrhizal networks (CMNs) has often been demonstrated, but the mechanism and significance of such nutrient movement in the field remains uncertain. Previously, we have demonstrated ^{15}N -movement between ectomycorrhizal (EM) pine (*Pinus sabiniana*) trees. In that study, arbuscular mycorrhizal (AM) plants surrounding EM trees received an equivalent amount of ^{15}N from the donor-tree, suggesting root exudation is an important transfer mechanism. In a follow-up experiment, we removed the grass vegetation between donor- and receiver-trees to test the hypothesis that more ^{15}N would move between trees in the absence of grasses in a Californian pine forest. We performed the following treatments: (1 and 2) ^{15}N application to donor-pine needles in the presence or absence of grasses and (3 and 4) with or without ^{14}N application to receiver-pine needles. We found that needle $\delta^{15}\text{N}$ values of receiver-pines (462‰) growing in the presence of grasses were significantly greater compared to receiver-pines (320‰) growing in the absence of grasses. Receiver-pine roots in the presence of grasses also became significantly more enriched (42‰) than pine-receiver roots (29‰) in the absence of grasses. The ^{14}N application to the receiver-tree reduced ^{15}N movement from tree to tree regardless of the presence or absence of grasses. Grasses appeared to facilitate the transfer of N between trees in all four treatments. The movement of ^{15}N to grass roots when present, expressed as concentrations, was similar to the receiver-pine roots. The movement of N from a pine rhizosphere and common EM network to a common AM network suggests that root and/or hyphal leakage is an important process that circulates N in the rhizosphere. Our results indicate that root exudation may be an important indirect transfer and reallocation mechanism of N and other nutrients among plants and diverse CMNs. Our results have important implications for nutrient movement between diverse plants in terrestrial ecosystems.

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POSTER ABSTRACTS
Poster session 3
Thursday 2 August

CR748MP

Area: Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Isotopic characterisation of an inshore tropical pelagic ecosystem

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The Bay of Panama is a tropical marine ecosystem with strong, seasonal upwelling, which drives production in the bay and draws in migratory animals to feed.

1. We present plankton isoscapes across the Bay of Panama based on $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ measurements in fresh pelagic particulate organic matter (POM) for organisms 200 μm , denoted as zooplankton. There are very large ranges in phytoplankton $\delta^{15}\text{N}$ (13 ‰) and $\delta^{13}\text{C}$ (8 ‰) and zooplankton $\delta^{15}\text{N}$ (14 ‰) and $\delta^{13}\text{C}$ (6 ‰) data over a three-month non-upwelling period.
2. A 10-month time series of $\delta^{13}\text{C}$ data from a resident trophic level (TL) 3 zooplanktivorous pelagic fish, the rainbow chub *Kyphosus ocyurus*, covaries with a time series of sea surface temperature (SST). SST values, and therefore *K. ocyurus* $\delta^{13}\text{C}$ values, vary seasonally, with cooler temperatures from deep, nutrient-rich waters in upwelling season and warmer temperatures during the rest of the year. The correlation between SST and *K. ocyurus* $\delta^{13}\text{C}$ values shows that there is local surface temperature control on $\delta^{13}\text{C}$ values in pelagic fishes in Panama Bay.
3. The transfer time from SST to *K. ocyurus* is approximately two months, suggesting a response lag of on average of one month per trophic level in the tropical pelagic ecosystem.
4. We measured tissue-diet spacing between *K. ocyurus* and sierra mackerel *Scomberomorus sierra*, a resident pelagic piscivore of approximately TL4. We also measured the isotopic compositions of yellowfin tuna *Thunnus albacares*, and mahi mahi *Coryphaena hippurus*, migratory TL4 pelagic piscivores, captured within the Bay of Panama and in open Pacific waters. Using the isotope values measured in resident *S. sierra* and in open ocean *T. albacares* and *C. hippurus* as end members, we can use the predicted spacing between TL3 and TL4 to discuss the likely residence time in the Bay of Panama for these migratory fishes.
5. We present tissue-diet spacing between primary production, zooplankton, zooplanktivores, and piscivores in a tropical pelagic environment.
6. Finally, we present an estimate of community-level predator-prey mass ratio for the Panama Bay ecosystem and discuss the implications for ecosystem structure.

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FB547HS

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Benthic-pelagic couplings as key determinants of food web structure along environmental gradients

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Trophic relationships play a crucial role in shaping community structure and ecological functions in marine ecosystems. Studying food-web variation along environmental gradients is still in its infancy and provides new insights in understanding how abiotic variables shape species interactions. In epicontinental seas, benthic-pelagic couplings modify predator-prey relationships and lead to entangled trophic networks. Here, we assumed that depth affects benthic-pelagic couplings' strength and we investigated depth-related changes in the feeding patterns of fish in the whole English Channel (EC) used as a case study. Gut content and stable carbon and nitrogen isotopes of 33 fish species were collected between 5-100 m depth in 2009 and in 2014. Samples from additional compartments of the ecosystem were also collected to delineate the whole food web. First, analyses on the general topology of the EC food-web indicated that it forms a continuum of four trophic levels with species falling into functional groups characterized by varying contributions of pelagic and benthic food sources. Further studies using Bayesian isotope mixing models (Isoweb) quantified that, at the whole EC scale, the main food sources for all fish functional groups were of benthic origin (>50%). However, a significant decrease in upper consumers' $\delta^{13}\text{C}$ variance and a significant increase in their $\delta^{15}\text{N}$ variance as depth increases suggested a reorganization of the trophic network along the depth gradient. Then, mixing models including depth as a continuous covariate (MixSIAR) successfully deciphered depth-related variation in feeding strategies that differed between fish functional groups. In shallow waters, fish species benefited from both pelagic and benthic prey whereas, in deeper waters, they fed predominantly on either benthic or pelagic sources depending on their habitat preferences. Benthic food contribution to the diet of pelagic and benthic species varied from 10 to 50% and from 50 to 100%, respectively. A focus on the isotopic niche (Niche Rover) of a subset of 10 species confirmed that depth structured species' niche position, breadth and overlap. Environmental gradients such as depth gradient should be used as proxies of benthic-pelagic couplings' strength to understand spatial variation in consumers' resource use and highlight varying energy pathways structuring marine food webs.

LF822TG

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

The invasive aquatic *Dikerogammarus villosus* - a dangerous killer or an opportunistic omnivore?

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Invasive species affect the food web structure and community dynamics through habitat modification and availability of resources, causing an increasing threat for native biodiversity, especially in freshwater ecosystems. One of the worst 100 invasive species in Europe is the ponto-caspian amphipod *Dikerogammarus villosus*. Its strong predatory potential, indicated by laboratory studies, is often assumed to be a key driver of declining macroinvertebrate biodiversity following its invasion. However, field studies suggest a more variable, omnivorous feeding of *D. villosus*, including the ability to change feeding preferences in different habitat and along a gradient of food availability. Those findings mostly originate from rivers, where this species had been established for more than a decade. *D. villosus* might still act as a strong predator during initial invasion, but shifts to an opportunistic omnivorous feeding after its establishment. We tested our hypothesis that *D. villosus* has more predatory and less opportunistic feeding in newly invaded rivers. We used bulk stable isotope analyses of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ to determine its trophic position and isotopic niche in three European rivers with a different invasion history using mesocosm experiments. Two of the rivers were invaded by *D. villosus* more than a decade ago, and the species established high densities. The communities in one of those rivers were dominated by invasive taxa but the other river still contained many native taxa. The third river was invaded more recently (~ 5 years ago), *D. villosus* occurs there at low densities, and its community is dominated by native taxa. Trophic position (TP) of *D. villosus* was calculated for each river using the R package *tRophicPosition*. This analysis revealed that *D. villosus* is not a predator in any of these rivers and its TP is not higher in the newly invaded river. We also estimated isotopic niche width an indicator of the opportunistic feeding of *D. villosus* using the R package *SIBER*. This analysis showed that the species might feed even more opportunistically in the newly invaded river, potentially suggesting omnivorous feeding could facilitate its invasion success.

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HT337KN

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Trophic overlap and isotopic niche breath of the mutton snapper (*Lutjanus analis*) along a Northeastern Brazilian mangrove-seagrass-coral reef continuum

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Lutjanidae includes species that are considered biological vectors connecting estuarine mangrove systems to coral reefs habitats. *Lutjanus analis* is commonly found in both ecosystems as well as associated to small stepping stones environments along this continuum, such as seagrass meadows and mixed seagrass and macroalgae beds. We studied a Northeastern Brazilian costal seascape where Mangrove is in the most inner part and coastal reefs the most outer zone. The mixed algae and seagrass site are small patches adjacent to the mangrove site while the seagrass meadows are small stripes located next to the river mouth, near the coastal reefs. We analyzed muscle tissues for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ stable isotopes (EA-IRMS) from 26 individuals collected during 2017 austral summer. We used Bayesian ellipses and Layman's metrics (SIBER, ranges, CD and MNND) to access the trophic overlap and isotopic niche breath by comparing the individuals collected in each site. There was almost no overlap in $\delta^{13}\text{C}$ range between sites with standard ellipses showing no overlap. $\delta^{13}\text{C}$ values were partially consistent with the expected, since the most depleted values were those from mangroves (C3 plants dominated area). However, most enriched individuals were those from coral reefs instead of the seagrass meadow (C4 plants). In fact, we observed a $\delta^{13}\text{C}$ gradient along the spatial continuum with individuals been gradually $\delta^{13}\text{C}$ enriched from mangrove ($\delta^{13}\text{C}$ average of -22.8‰) to mixed algae and seagrass ($\delta^{13}\text{C}$ average of -18‰) through the seagrass meadows (C4 plant dominated; $\delta^{13}\text{C}$ average of -16.3‰) to coral reefs (algae and marine phytoplankton; $\delta^{13}\text{C}$ average of -14.2‰). The SEAc areas showed a higher niche for individuals from Reefs (7.6) followed by those from Seagrass (2.4) and Mangroves (1.6). Individuals from the algae and seagrass mixed site were very constricted in both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values, with SEAc of 0.2. Inclusion of more individuals as well as to incorporate food sources and baselines could help to evaluate in a finer scale the resource use and trophic position along this environmental continuum.

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Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Seasonal variation of harbour seal diet from the Wadden Sea, in relation to prey availability

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The Wadden Sea, stretching along the coast of the Netherlands, Germany and Denmark, has an important role for marine mammals in terms of resting, nursing and foraging. The Harbour seal (*Phoca vitulina*) is the most abundant marine mammal species in this area. Currently the dietary composition and foraging behaviour of harbour seals in the Wadden Sea is not clear. Previous studies have shown that this species can travel kilometres away from their haul-outs to forage in the North Sea. In this study, we analysed the stable isotopes of whiskers and muscle from dead harbour seals found on the island of Sylt in the Northern Wadden Sea from 2012 to 2016, to investigate their diet and foraging location. First, we studied the temporal variation of stable isotope composition of young-of-the-year and adults to determine from which point in time the isotopic composition of the young-of-the-year tissues (i.e. muscle and whisker) are no longer influenced by lactation and post-weaning fast. We compared the carbon and nitrogen isotope compositions of whiskers from individuals not influenced by lactation and post-weaning fast, to those of different potential prey items from both the Wadden Sea and the North Sea. Isotopic samples were representative of a seasonal cycle, and in parallel, seasonal variation in the abundance and biomass of the potential prey items from the Wadden Sea were studied and compared to their contribution to seal diet. The results revealed a change in seal diet from pelagic sources in spring to a benthic based diet in summer, and an increasing use of the North Sea resources in fall and winter in accordance with the seasonal variation of the availability of prey in the Wadden Sea.

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Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Benthic trophic structure of a glacial fjord (Northern Patagonia, Chile): spatial variability of isotopic niche

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The complex Martínez-Baker fjord system (MBFS, 47.5°S) is a highly stratified fjord, located between Northern and Southern Patagonian Ice Fields and influenced by the Baker river, which exhibiting a strong lateral coupling (river-ocean). The freshwater discharges contribute with high levels of suspended solids (SS) that limited the input of organic matter from primary production to benthic communities. We examined benthic trophic structure along the inner, middle and outer sections of the MBFS using carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) stable isotope ratios. A combination of different gears was used to obtain specimens. Additionally, SS and particulate organic matter from river and superficial sediment were sampled in order to identify potential food sources. A total of 41 species were identified. Decapod crustaceans were the dominant group in the inner and middle fjord sections, but the middle section incorporates other groups that were not found in the Inner section, such as Cnidarians and diverse kind of echinoderms. According to SIAR analysis, our results indicate that there are significant differences in stable isotope values of $\delta^{13}\text{C}$ from organic material associated with sediment among sections ($p=0.009$). This result suggests that trophic structure in the study area is fuelled by primary production, but there are gaps in the potential food sources such as epilithic biofilm, cyanobacterias and fungal communities that could play an important role in the food web in this glaciofluvial environment, but their role remains unknown. The trophic structure metric suggests differences in the isotopic niche width to predators, such as crustaceans and fishes. Contrasting, amplitude of niche appears to be different when compare the inner and middle fjord. In the middle section, echinoderms and mollusks seems to be generalist consumers with a broad isotopic niche suggesting the use of a wide range of resources, and the overlap between groups may suggest a non-selective feeding. It is thus concluded that trophic benthic structure at the MBFS is controlled by local environmental conditions, sustaining a community with a wide range of food sources autochthonous (phytoplankton and macroalgae) and allochthonous organic matter.

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Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

A decade of diet analysis: dietary shifts of the Southern hake and the Patagonian grenadier inferred by stable isotopes

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The analysis of stable isotopes $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ of two important fishery species were performed (*Merluccius australis* and *Macruronus magellanicus*). We used that the isotopic values of vertebrae structures with a continuous growth, which allows having a detailed information about diet. This approximation permits the reconstruction of the life history of an individual. The results showed a positive trend in the ^{15}N enrichment with increased sampling distance from the vertebrae center, indicating a relation between body size and $\delta^{15}\text{N}$. The three levels of growth evaluated showed values between $10.84 \pm 2.18 \text{ ‰}$ and $12.87 \pm 1.53 \text{ ‰}$ $\delta^{15}\text{N}$ in *M. australis*, whereas in *M. magellanicus* they were between $10.4 \pm 1.3 \text{ ‰}$ and $12.5 \pm 1.7 \text{ ‰}$ $\delta^{15}\text{N}$. $\delta^{13}\text{C}$ analysis showed a change in the use of the feeding environment as the organism grows. This change was significant for southern hake whose values were between $-13.23 \pm 1.07 \text{ ‰}$ and $-12.53 \pm 1.02 \text{ ‰}$ $\delta^{13}\text{C}$. In addition, the use of coastal waters as the main spawning area for both species was corroborated. The results generated allow us to affirm the importance of the use of isotopes as tools for the management of fishery resources, as they provide information at different scales of time and space. That is of vital importance for the study and understanding of population dynamics.

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Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

How to implement stable isotope analyses into ecotoxicological risk assessment of chemicals using aquatic mesocosm experiments?

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Environmental risk assessment of chemicals (pesticides, biocides, etc.) is based on comparison of predicted or real exposure concentrations in the field and ecotoxicological effects of different organisms representing different trophic levels. Classic ecotoxicological endpoints which affect the population level are e.g. mortality and reproduction. Data are derived from short-term or chronic mono-species testing in the lab, and can end up on mesocosm experiments if more complex interactions of the test substance and/or the organism communities have to be assessed. However, shifts in the food web structure as the results of various direct or indirect effects, which may also affect the species community on the long-term run, are disregarded up to now. Here, we suggest a first step how to include potentially regulatory relevant data from the food web structure of aquatic mesocosm experiments to environmental risk assessment. Thereby, it is essential to keep in mind that each risk assessor evaluates various data provided for assessment of a substance, and guidance on study conduction and data evaluation is prerequisite for an implementation into environmental risk assessment. In two experiments investigating the effect of low-dose pesticide mixtures in aquatic mesocosms, we used bulk stable nitrogen and carbon isotope analysis of invertebrate taxa additional to parameters like density of invertebrates, and emergence patterns of merolimnic insects. At the end of both experiments, trophic level of the omnivorous freshwater amphipod *Gammarus roeselii* was affected, indicating an effect of the pesticides mixtures on the food web structure. Based on the results of the first experiment, the amount of sampled taxa was expanded in the second experiment in order to enable more detailed description of the food web structure. Considering six taxa, abundant in all control mesocosms, and two primary resources, we calculated Layman community metrics of which especially total area of convex hull and carbon signature range showed a clear inverse U curved response in relation to increasing pesticide toxicity. These first results indicate that stable isotope analysis might be a promising tool to derive regulatory relevant data quantifying direct and more importantly indirect effects of chemicals on taxa using (aquatic) mesocosm experiments.

KG165GK

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

A trophic baseline for the Wadden Sea: Examination of the contributing pathways leading to widespread enrichment of basal resources.

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Compound specific analysis of amino acids is a useful tool for tracking trophic relationships within ecosystems that is increasingly being adopted by ecologists. Application of compound specific analysis for $\delta^{15}\text{N}$ using selected amino acids has allowed for increased precision in the accounting of trophic position within diverse communities (Ishikawa *et al.*, 2017) and has allowed for characterization of a trophic baseline within the ecosystem with limited direct analysis of the basal resources being utilized within the ecosystem (McMahon and McCarthy, 2016). Isolation and comparison between the amino acids glutamic acid (GLU) and phenylalanine (PHE) allow for simultaneous identification of both the trophic position of the examined species as well as a trophic baseline for the ecosystem that the species resides in. In the Wadden Sea, previous analysis for the $\delta^{15}\text{N}$ values for bulk material indicated considerable widespread enrichment across both predators and primary consumers. Further compound specific analysis for the amino acids GLU and PHE for the same species indicated considerable enrichment for the PHE in all species examined. Previous work has indicated the widespread dominance of carbon derived from benthic primary producers contributing to the food web in the Wadden Sea (Christianen *et al.*, 2017). Widespread enrichment in $\delta^{15}\text{N}$ across species potentially indicates a common pathway throughout the ecosystem that has resulted in considerable enrichment for basal resources. Here, we investigate potential processes occurring within the coastal environment that have caused considerable enrichment in basal resource values. We will also discuss the effect that this enrichment has had on the trophic discrimination factors calculated for individual species within this ecosystem.

DK352DR

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Characterising trophic ecology and evidence for stock structure in the punctuated snake-eel (*Ophichthus remiger*) using analysis of stable isotopes, fatty acids and metal concentrations.

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The punctuated snake-eel (PSE) is a medium-sized (max length 120cm), demersal marine fish found in the coastal waters (depth 10–450m) of the SE Pacific (Nicaragua to Chile). They are cryptic, spending most of their time buried in sand or soft sediments, with only their heads exposed. Trap fisheries for PSE are growing in the region reflecting increasing demand from Asian markets, raising interest in the species as a candidate for aquaculture. However, little is known regarding their basic biology, e.g. understanding of PSE diet is constrained by the fact that most individuals (>80%) captured have empty stomachs. The species potentially plays an important role in benthic habitats as it can be locally abundant and the few data that are available indicate that it has a relatively high trophic position. There is no information on PSE stock structure. The lack of knowledge regarding the ecology of the species prevents proper management of this potentially important resource, and constrains development aquaculture. Here we use analysis of PSE stable isotopes ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) and fatty acids from three locations from the Pacific coast of N Chile to investigate the principle sources of energy supporting PSE populations (phytoplankton or kelp) and to estimate PSE trophic level. We also examined evidence for site fidelity by examining whether PSE captured from different locations had distinct stable isotope, fatty acid or metal (Cd, Cu, Pb & Zn) concentration 'fingerprints'. SIA results PSE muscle was almost purely synthesised from pelagic-derived C and N, supported by large concentrations of pelagic-associated PUFA biomarkers. PSE $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values differed between the three locations, partly reflecting different oceanic conditions, but they also differed in trophic position, suggesting local variation in trophic ecology. Metal concentrations also differed between locations. Discriminant function analysis showed that SIA and metal analyses had a similar capacity to predict capture location (jack-knifed classification success = 92%), but fatty acids discriminatory power (60%) was reduced, potentially due to reduced sample size. The combination of SIA and metal data raised classification success to 97%, indicating that most PSE show considerable fidelity to a given location.

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LG698CG

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Isotopic niche overlap of predators with high trophic levels off the coast of Chile

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High trophic level predators (HTLP), play important functional roles in ecosystems because they perform a top-down control over the community. Moreover, these fishes are susceptible to the changes that occur at the lower trophic levels. Therefore, reductions in HTLP and their prey abundance can generate an increase in HTLP diet overlap. In Pacific waters, the mass of large predators such as swordfish and sharks removed by fisheries increases each year. However, stocks of swordfish and blue shark stocks do not seem to be affected, given that fishery, yield estimation tends to increase, contrary to what was observed for mako shark stock. When predators and prey abundance decrease, predators tend to show a high diet overlap. To evaluate the dietary overlap on HTLP of the open ocean Pacific ecosystem, stable isotopes analyses were performed. Muscle samples were obtained among the years 2011 to 2016. The results indicated that there was a low niche overlap, except for 2016, when swordfish, sharks, tunas and schooling fishes, had a high overlap (>50%). Finally, this study does not provide evidence of a highly impacted ecosystem, yet results from 2016 require a deep data analysis, including more direct dietary assessments and the addition of extra years to see whether the change was temporary or has continued over time continuous over time.

Universidad Andrés Bello, Instituto de Fomento Pesquero

LG822PB

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Isotopic niche plasticity in a marine top predator.

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The Magellanic penguin (*Spheniscus magellanicus*) breeds in a broad latitudinal range (40-55° S) along the Atlantic and Pacific coasts of South America. During breeding, this species is a central-place forager, and feeds mainly on schooling fish, with anchovy (*Engraulis anchoita*) being the dominant prey in the north, and sprats (*Sprattus fuegensis*) in the south of the Atlantic distribution. Like most forage species, both species display large recruitment fluctuations between years. We use stable isotope analysis sampled in adult penguin blood from colonies in the Atlantic latitudinal range (350 birds) to assess the changes in isotopic niche and trophic level as response of seasonal changes and spatial segregation of forage fish size classes. We found that Magellanic penguin has large isotopic niche fluctuation during six consecutive reproductive seasons. Furthermore, the size of the isotopic niche negatively correlates with forage fish biomass estimated from acoustic surveys. In addition, the trophic level of penguins increases with latitude, which corresponds to size-distribution of both main forage species, showing that penguin from different colonies target different size classes of its main prey.

Agencia Nacional de Promoción Científica y Tecnológica

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Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Evaluating invertebrate grazer reliance on seagrass (*Zostera* sp.) or filamentous algae in seagrass meadows in different state of deterioration

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Seagrass (*Zostera* spp.) meadows are keystone habitats supporting high biodiversity, marine food production and climate change mitigation. Unfortunately, they are also among the most threatened ecosystems on the planet and for effective management strategies, the direct role of *Zostera* sp. as a food source needs to be assessed. In this study we analyse stable isotopes of carbon, nitrogen and sulphur in bulk samples of invertebrate consumers associated directly or indirectly to *Zostera* from two systems where filamentous algae are increasing as a consequence of eutrophication and global warming: the Baltic Sea (Sweden) and Langebaan estuary (South Africa). In addition, we analyse the nitrogen isotope composition of amino acids (AA-SIA) in invertebrates. We expected species belonging to different functional feeding groups to feed to a various degree on these two potential food sources. Both bulk carbon and the phenylalanine (Phe) nitrogen isotope composition clearly differed between algae and seagrass, however comparing consumer signals directly to these values gave conflicting results. There was some support for seagrass as a diet source. We highlight the need for a multi-isotope approach when disentangling food web structure in complex systems.

LR662GH

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Global-scale analysis of trophic interactions in co-occurring tropical tuna using stable isotope analyses

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Tropical tuna fisheries are of vital importance to many developing countries as they heavily depend on these industries for food security and national income. Knowledge on trophic interactions among species present in these fisheries is essential to understanding food-web dynamics supporting tuna populations and how these may alter with climate-driven changes and intensive fishing activities.

Using stable isotope analyses, we investigated the trophic interactions of four co-occurring tuna species including the yellowfin tuna *Thunnus albacares*, the bigeye tuna *Thunnus obesus*, the albacore tuna *Thunnus alalunga* and the skipjack tuna *Katsuwonus pelamis*.

We used Bayesian mixing analyses of isotopic niche metrics to examine the spatial variation of dietary overlap among these species across 3 regions in tropical oceans. We showed that interactions among these same species can differ between neighbouring biogeochemical provinces (e.g. Pacific regions). Our findings suggest that resource partitioning and foraging behavior of tropical tuna species is linked to intrinsic conditions of oceanic regions such as strong seasonal upwelling events.

MB866MB

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Isotopic trophic guild structure of demersal fishes in Campos Basin, northern coast of Rio de Janeiro, Brazil.

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The trophic guild structure of demersal fishes was investigated based on stable isotopes of carbon ($\delta^{13}\text{C}$), nitrogen ($\delta^{15}\text{N}$), Bayesian ellipses and Layman metrics in south-western Atlantic (22°S). Fishes were sampled with bottom trawls between 40 to 60 m depth on the northern coast of Rio de Janeiro state Brazil, in September 2015. Species identification and isotopic analysis were conducted in the laboratory and trophic guilds were defined based on specific literature. A total of 153 specimens distributed in 14 species were identified and assigned to four trophic guilds: carcinophagus ($n = 6$; *Prionotus nudigula*), carnivorous ($n = 10$; *Atlantoraja cyclophora*, *Diplectrum radiale*, *Gymnothorax ocellatus*, *Ogcocephalus vespertilio* and *Priacanthus arenatus*), invertivorous ($n = 83$; *Dactylopterus volitans*, *Upeneus parvus* and *Zapteryx brevirostris*) and piscivorous ($n = 54$; *Fistularia tabacaria*, *Lophius gastrophysus*, *Percophis brasiliensis*, *Synodus foetens* and *Synodus myops*). The isotopic signatures were heavier for piscivorous (ANOVA, $p < 0.05$) and lighter for invertivorous (ANOVA, $p < 0.05$). While $\delta^{13}\text{C}$ ranged from -18.6 ± 0.9 ‰ to -17.7 ± 0.6 ‰, $\delta^{15}\text{N}$ ranged from 11.1 ± 0.9 ‰ to 12.7 ± 0.8 ‰ for invertivorous and piscivorous, respectively. The highest standard ellipse area (SEA = 1.7 ‰²) and trophic diversity (mean centroid distance: CD = 1.1 ± 0.5 ; ANOVA, $p < 0.05$) were observed for invertivorous species. While the highest ellipses overlaps were observed between carnivorous and invertivorous (38.1 %) the lowest was between piscivorous and carcinophagus (0.2 %). In conclusion, the broader isotopic niche breadth was observed for invertivorous demersal fishes. Furthermore, the isotopic niches of the four demersal fish trophic guilds were clearly distinct from each other, reflected by the low level of overlaps between its isotopic niche ellipses.

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Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Reef fishes' trophodynamics between trawled and non-trawled environments

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Temperate reef fishes from western Patagonia are long living animals, with low energy budget and high site fidelity. They present complex reproduction strategies and low reproduction potential, which make them particularly vulnerable to local impacts. Trawl fisheries impact the environment by removing target animals, producing discards and scrapping the sea bottom: factors that can alter the availability of different prey. We studied the trophodynamic of two reef fishes of Western Patagonia: Argentine sandperch; *Pseudoperca semifasciata* and Argentine seabass; *Acanthistius patachonicus*. Previous studies suggested that the seabass feeds more on soft bottoms preys and less on water column preys than the sandperch. Also, a broader diet and foraging range was described for the sandperch. Diet features were compared between trawled and non-trawled areas using stable isotope analysis of C and N along an overlapping size range. At trawled areas, isotopic niches were wider (area P_s : 0.34, area A_p : 0.64) and overlapped more (0.1) than at non-trawled areas (area P_s : 0.32, area A_p : 0.11; niche overlap: 0.04). Trends along body sizes were non-significant for the seabass ($p > 0.05$). The sandperch showed significant trends of $\delta^{13}C$ values vs size only at trawled areas ($p = 0.004$), while trends of $\delta^{15}N$ values vs size were significant only at non-trawled areas ($p = 0.005$). The seabass expanded its trophic diversity at trawled areas, which could be a consequence of an increased availability of soft bottom preys by surface scrapping and/or the usage of discards. Regarding the sandperch, trophic level was expected to increase as they become bigger. This prediction was met at non-trawled areas, while at the trawled site, diets were relatively constant through sizes. Trends in $\delta^{13}C$ values vs size could also be reflecting the availability of more benthic preys on impacted environments. Finally, fishes at trawled areas seem to have more similar diet showing less niche partitioning. This is one of a few cases where theoretical changes on trophic features between trawl and non-trawled environments were actually found, and the differences in trophodynamic features between species sets a good scenario to capture its complexity.

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Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Is C and N isotope turnover of amino acids a function of dietary protein and protein to energy ratios in marine fishes?

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Marine fishes have complex life cycles that frequently involve stage-specific habitat utilization and complex migration patterns. Carbon (C) and Nitrogen (N) stable isotope analysis (CSIA) of amino acids (AA) have served as natural tracers of habitat use and migration at the individual level, particularly for species that transition between different habitat types or use multiple habitats that differ in isotopic baselines. Specifically, AA $\delta^{15}\text{N}$ values can be used to characterize isotopic baselines and estimate trophic level. Because isotopic turnover (IT) defines the period of time and growth required for a tissue to reflect the isotopic composition of an assimilated new diet, accurate estimates from metabolically active tissues are essential to effectively use AA isotope values to trace habitat use, movement and dietary shifts. To integrate information from both elements (C and N) and quantify IT in AAs, we conducted a 98-day controlled feeding experiment on Pacific yellowtail (*Seriola lalandi*). Juveniles were fed with isoenergetic formulated feeds containing 40, 50 and 60% of high-quality protein. Dietary protein content is the main driver of biomass gain (growth) in growing marine fishes, and protein-energy ratios (P:E) play an important role in regulating the extent of protein catabolism and can therefore influence metabolic turnover (defined as the loss of existing biomass due to catabolic processes). Hence, we evaluated the relationship between dietary protein levels, P:E ratios and IT for each source (i.e. Phe, Lys, Met, Gly) and trophic AA (Ala, Asp, Glu, Iso, Leu, Pro and Val) in liver and muscle tissues. The relative contribution of biomass gain and metabolic turnover to IT will be examined as a function of protein content and P:E ratios using both time and growth-based models. The results of this study will advance the application of CSIA-AA on wild fish populations to evaluate dietary changes during their life cycle and reconstruct habitat use, connectivity and migration patterns.

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Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Carbon source for cachama blanca in farmponds in Orinoco region

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The cachama blanca, *Piaractus brachypomus* is the most cultivated native fish species in Colombia, mainly in the region of the Llanos Orientales. In its natural environment the carbon source for cachama is provided by C₃ plants (-28 δ¹³C) and maximum 21% carbon came from C₄ plants, however, in farm ponds, the food supplied is commercial pellets of unspecified components. This study aimed to identify carbon source for cachama in cultivation. The work was conducted at the commercial aquaculture (4°57'N; 73°94'O), in Orinoco region, Colombia, between May and September 2010. The work was performed in three ponds fish (1,600m²), with water change; for one production cycle. Muscle (n=15) and sediment (n=14) samples were collected monthly. The sediment from the superior, center and inferior margin were collected at each pond; the corresponding samples were mixed for each pond to minimize the errors caused by characteristics heterogeneity of the sediments. The analyses of δ¹³C samples were conducted at Georgia University, USA. The contribution of commercial food assimilated by the cachama was estimated on δ¹³C data in R-project. The isotopic muscle tissue fish signatures the cachama (-27.49; -18.60 δ¹³C) overlap of a range of the food (-20.8±0.1 δ¹³C). Thus, our results suggest that a significant portion of the cachamas assimilated nutrients derived from commercial food. However, these are also assimilating carbon from the sediment (-24.30±1.45 δ¹³C); this could be explained by the use of nutrients in the resuspension of sediments. On the other hand, the contribution carbon derived from C₄ plants was not identified. We report values within this range for cachama (-20.71±1.08 δ¹³C) in other commercial fish farms, as well as in an experimental pond (-18.71±0.49 δ¹³C) when feeding a 50:50 diet, C₃: C₄. Thus, in natural environment and culture, the principal source of energy for *P. brachypomus* derives from the C₃ plants.

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Carbon source for coporo llanero *Prochilodus mariae* in farmpond

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Detritivorous fishes are widely distributed in neotropical rivers and their carbon is generally derived from C₃ plants. In the Amazon river for example the carbon signatures for these fishes was of $-33.65 \pm 1.29 \delta^{13}\text{C}$ and protein consumed is approximately 20%. The detritivorous bocachico llanero *Prochilodus mariae*, is one of the most popular freshwater fisheries in Orinoco region Colombia. However, in aquaculture *P. mariae* is slow growing and the food supplied is commercial pellets of unspecified components with high protein value. This study aimed to identify the foods contributing to bocachico llanero growth in fertilized ponds. The experiment was conducted in a pond (600 m² fertilized in advance with dried cattle manure), over 120 days. Muscle tissue samples from two fishes groups (adults-1 and juvenile-2), as well samples of particulate organic matter POM, grasses, detritus, and periphyton from the ponds were collected for stable isotope $\delta^{13}\text{C}$ analysis. The samples were taken at the beginning and the final of the experiment. The contribution of sources potentially assimilated by the fish was estimated based on $\delta^{13}\text{C}$ data using the SIAR mixing model in R. The putative food item closest to isotopic equilibrium with muscle tissue of adults and juveniles (-20.6 ± 1.6 , $-21.7 \pm 0.63 \delta^{13}\text{C}$) was POM ($-22.5 \pm 0.83 \delta^{13}\text{C}$). Detritus did not make a significant contribution ($-19.1 \pm 3.1 \delta^{13}\text{C}$), likely because it was derived from C₄ sources. We report values within this range for bocachico llanero ($-21.44 \pm 0.84 \delta^{13}\text{C}$) in polyculture pond with *Piaractus brachypomus* when feeding a 50:50 diet, C₃: C₄. Our results show than both groups are highly selective, the small change in $\delta^{13}\text{C}$ between the diet and fish suggests that the majority of carbon assimilated in diet is derived of C₃ plants. Thus, both in the natural and cultured environments, the principal source of energy for *P. mariae* derives from the C₃ plants.

Universidad de Los Llanos/Dirección General de Investigaciones, Project: carbon sources in ponds fish/Instituto de Acuicultura de los Llanos-IALL/Grupo Granac

QQ267RP

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Diet evaluation of *Demochelys coriacea* with stable isotopes in the Colombian Caribbean

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Sea turtles play an essential role for diverse environments, they help to balance the populations of organisms that represent a risk for these ecosystems, ensuring the nutritional quality in the oceans and fertile beaches. Sea turtles are highly migratory, for this reason, many authors consider that it is important to know the connection between the feeding and reproduction zones, where the environmental conditions and the dangers are exposed; which leads to the necessity of investigating more deeply other aspects of this group not only with satellite telemetry and population genetics, but also of trophic ecology as a complement to expand the information. The determination of stable isotopes, that are in nature, in chemical products, physical and biological reactions, makes it possible its applicability in migratory studies of various groups including sea turtles, allowing to infer and knowing the habitats that have been occupied only for foraging and which for reside, since the isotopic signal will depend on the locality where they are fed. Thus, we conducted isotopic analysis of carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) from the muscle and bone of 48 neonates of *D. coriacea* captured in Santa Marta region, in order to infer which are the feeding areas of their mothers and at what trophic level they fed at. The mean (\pm SD) values for $\delta^{13}\text{C}$ were -21.02 ± 0.84 ‰ (range between -23.08 to -19.19 ‰) and 9.54 ± 0.44 for $\delta^{15}\text{N}$ (range between 8.74 to 10.21 ‰). These data suggest that possibly their mothers (the neonates likely originated from two or three different mothers) tends to feed in oceanic areas according the low values of $\delta^{13}\text{C}$ before their arrival at the nesting beaches. The values of $\delta^{15}\text{N}$ were relatively high, suggesting the consumption of possibly a second order prey, such as some crustaceans, fish or cephalopods.

Universidad de Bogotá Jorge Tadeo Lozano. Proyecto Ecología y Biología del Pez León en dos Ambientes del Caribe Colombiano. Convocatoria No. 12 y 16 de 2015, 2016 de la Dirección de Investigación, Creación y Extensión.

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Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Isotopic niche comparison among three coastal cetaceans from southern Brazil

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The ecological niche of a species can be assessed by its isotopic niche, as stable isotopes can give insight into its biogenic (diet) and the scenopoetic (habitat) dimensions. We compared the stable isotopic composition ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) in tooth collagen of three coastal cetaceans co-occurring in southern Brazil: the Guiana dolphin - *Sotalia guianensis* (n=35), the franciscana dolphin - *Pontoporia blainvillei* (n=38) and the common bottlenose dolphin - *Tursiops truncatus* (n=14). We performed ANOVA with Tukey tests to evaluate differences in the isotopic composition of the species. To estimate the degree of niche overlap, we calculated the standard ellipse area corrected for small sample sizes (SEAc) and ellipses area overlap through SIBER (Stable Isotope Bayesian Ellipses in R). No differences were found for $\delta^{13}\text{C}$ values (*P. blainvillei* = $-14.51 \pm 1.84\text{‰}$; *S. guianensis* = $-14.39 \pm 1.75\text{‰}$; *T. truncatus* = $-13.59 \pm 1.21\text{‰}$). However, significant higher $\delta^{15}\text{N}$ values observed for *P. blainvillei* ($18.0 \pm 1.1\text{‰}$) suggests a higher trophic position than the other species. Additionally, *P. blainvillei* had the broadest niche width (6.49‰), probably using a wider range of prey than the other species. *T. truncatus* showed a lower $\delta^{15}\text{N}$ value ($15.90 \pm 1.48\text{‰}$) and SEAc (6.03‰) than *P. blainvillei*. No overlap was found among the isotopic niche of *P. blainvillei* and the other species. The lowest $\delta^{15}\text{N}$ value ($15.4 \pm 0.9\text{‰}$) and SEAc (5.08‰) observed for *S. guianensis* suggest a low trophic level feeding habit with a more specialized trophic niche. The ellipses of *S. guianensis* and *T. truncatus* showed an overlap area that represents 62% of the SEAc of the former and 52% of the latter, indicating that these species share a considerable proportion of their isotopic niche. Additional data about diet composition estimated using stable isotope mixing models will help to understand the isotopic niche partition and overlap of the three species in Southern Brazil.

Cetacean Society International (CSI) and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES)

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Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Stable isotope analyses of archived blue mussels from long-term environmental monitoring programs in the Baltic Sea

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Archived samples from long time-series of monitoring programs offers an unique opportunity to measure e.g. stable isotopes of carbon and nitrogen, thus providing quantitative information on changes in consumer diet and nutrient cycling over time. When combined with monitoring data on eutrophication and climate related variables, specific hypothesis on food-web and ecosystem responses to environmental change can be tested. The bivalve *Mytilus edulis* completely dominates the Baltic Sea benthic biomass and strongly influences benthic-pelagic coupling through its suspension-feeding activity.

Here, carbon and nitrogen isotopes as well as body condition of *M. edulis* individuals from the national monitoring program of the phytobenthic community in the Baltic Sea during the last 25 years are presented. Isotope data are tested for temporal preservation effects and isotopic niche metrics are calculated and compared among years. Variability in absolute isotope values, isotope niche metrics as well as body condition of mussels is regressed against monitoring data on cyanobacterial bloom intensity and abiotic variables such as salinity and temperature.

PJ883RS

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Diel changes in the structure and isotopic diversity of coral-reef invertebrates at Easter Island

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The nocturnal movements of invertebrate taxa play an important role determining the structure of communities and trophic relationships in one daily scale. The diel changes in the marine community structure have been sparsely considered in the sampling procedures, underestimating the diversity, composition of species and the food web architecture. The stable isotopes analyses emerged as an important tool being a robust proxy used for trace energy and matter fluxes through food webs and for describe the trophic structure of marine communities. Easter Island or “Rapa Nui” is a remote island situated near to the South Pacific subtropical gyre and harbor coral-reef communities which in comparison with other regions are considered depleted of fauna. The community structure has been described in the last time, but detailed studies on diel changes in the benthic assemblages and on the trophic structure even are necessary. Therefore, the aims of this study include: i) determinate diel changes in the richness, abundance and biomass of the invertebrate assemblages and ii) describe whether these potential changes may impact the trophic structure (using isotopic diversity indices weighted by biomass).

A total of 33 invertebrate taxa were identified on transect surveys with contrasting differences in richness and abundances between day and night surveys at Easter Island. Lower abundances were observed at diurnal surveys (224.5 ± 79.4 individuals 100 m^{-2}) and higher abundances at nights (551.2 ± 56.8 individuals 100 m^{-2}) ($t = -3.15$, $df = 5$, $p = 0.025$). Also lower richness were found at diurnal surveys (5.8 ± 0.6 taxa 100 m^{-2}) compared with nights (15.5 ± 1.3 taxa 100 m^{-2}) ($t = -8.90$, $df = 5$, $p < 0.001$). Moreover, the dissimilarity between day and nights surveys was 60 %. Conversely, day and night comparison on the isotopic functional diversity of invertebrate assemblages suggest differences in their trophic structure, where nocturnal assemblage have lower isotopic richness in contrast with diurnal assemblages (given by convex hull area), a lower isotopic divergence and dispersion (lower trophic specialization), lower isotopic evenness (higher trophic packaging) and a lower isotopic uniqueness (higher trophic redundancy).

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Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Ontogenetic change of trophic niches by the Argentine hake (*Merluccius hubbsi*) evaluated with stable isotopes

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Among those factors that determine the success of a fish cohort, trophic interactions play a key role, especially during the larval and juvenile stages. The Argentine hake (*Merluccius hubbsi*) is the most abundant demersal fish in the Southwestern Atlantic, and also one of the main commercial resources for Argentina. By employing C and N stable isotopes analysis (SIA) we evaluate *M. hubbsi* changes in trophic position and trophic niche throughout they early life from early larvae to juveniles 2+, (8 to 300 mm total length (TL)). We analyzed 124 hake individuals and 7 possible resources in different sectors as fish move from the spawning to the nursery ground in the coastal region of northern Patagonia. Mixing models considering 6 hake size classes showed an almost exclusively contribution of calanoid copepods to the diet of hake early and advanced larvae (8 to 33 mm TL). The importance of copepods as prey diminished while hakes increased in size with small contribution in juveniles between 36 and 120 mm TL (juveniles 0+) and negligible contribution in the largest size classes. Juveniles 0+ showed the most uncertainty in diet contribution with the amphipod *Themisto gaudichaudii* and *Euphausia lucens* gaining importance in diet. Juveniles 1+ and 2+ (between 120 and 300 mm TL), which have completed the settlement process, showed a high contribution of benthic items such as the squat lobster *Munida gregaria* and shrimps and mysids in their diet. Isotopic niche width (evaluated with SIBER) was greater in 0+ juveniles than the other stages indicating a transition between the pelagic and demersal diet. Trophic relationships determined in this work show that hakes occupy at least three different trophic niches during their larval and juvenile stages. Although the species shows a generalist feeding behavior, the different stages have a degree of specialization. This use of different resources can change the connection between distant habitats and the benthic pelagic coupling increasing community complexity which in turn can be relevant to community persistence.

QK698HH

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Estimates of primary production sources to Arctic bivalves using amino acid stable carbon isotope fingerprinting

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Benthic invertebrates are a crucial link in trophic energy transfer in the Arctic Ocean shelf habitats. However, the organic matter sources sustaining these organisms are not well understood. They could theoretically feed on particulate organic matter sinking from sea ice algae, phytoplankton, terrestrial organic matter eroded from the coastal environment, or microbially reworked organic matter. The proportional contributions of each of these sources to benthic organisms are not clear, but proportions might be significantly altered with future environmental changes. We have applied stable carbon isotope fingerprinting of essential amino acids to a broad suite of Arctic organic matter sources to use them as endmembers to compare in analyses with consumers. We are applying the fingerprinting method to essential amino acids preserved in bivalve shells as an archive to identify temporal variation in the proportional input of organic matter sources in benthic invertebrate species. A comparison of the isotopic signatures preserved in *Macoma* spp. and *Serripes* spp. revealed that they obtained their essential amino acids from different primary production sources. We also found that the signatures from muscle samples were very similar to those from the shells, implying that shells from fossil or archaeological records could be used to examine long-term changes in organic matter sources into the Arctic marine ecosystem. Future directions will include analyses of archaeological bivalve samples from Utqiagvik, Alaska to establish a pre-industrial baseline. Identifying how organic matter pathways have changed both over long timescales and in recent years will yield a better understanding of how current changes could alter Arctic ecosystems.

Coastal Marine Institute, Bureau of Ocean Energy Management

RM467SB

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Trophic niche of three bird species in northeastern Venezuela: spatial variation in a xerophytic environment

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The studies on niche allow to evaluate the use of food resources in species within a population or community. In this study we assessed changes in the trophic niche using the stable isotopes of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in two pigeons, *Columbina passerina* and *C. squammata*, and the Tropical Mockingbird, *Mimus gilvus*, in two xerophytic habitats: shrub and dry forest in the Araya Peninsula, state of Sucre, Venezuela. We captured individuals during five months in 2011, of which collected between 80 and 200 mL of blood from brachial vein of each individual. Stable isotope analysis was performed on 122 blood samples. We calculate the niche breadth by using a Bayesian approach and Stable Isotope Bayesian Ellipses in R (SIBER). *Columbina squammata* had the largest niche breadth (SEAC = 8.8 ‰²), followed by *C. passerina* (SEAC = 5.7 ‰²) and *M. gilvus* (SEAC = 5.1 ‰²). The size of the SEAC varied depending on the habitat; *C. squammata* and *M. gilvus* had a greater niche breadth in the thorny shrub, while *C. passerina* had a largest niche breadth in the dry forest. This variation of the niche breadth in the two habitats may result from the interindividual feeding behavior. The SEAC showed that *C. squammata* presented niche overlap with both *M. gilvus* and *C. passerina*; while *M. gilvus* and *C. passerina* did not reflect any overlap in their diets. However, *C. passerina* and *C. squammata* showed a significant diet overlap, indicating that both species have diets with similar isotopic signatures. The characteristics of the two environments would greatly influence the feeding behavior of the birds and prey selection, reflecting generalist or opportunistic behavior.

Instituto Venezolano de Investigaciones Científicas (IVIC)

RS291GM

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

**Evaluation of the effects of kelp harvesting on trophic ecology of redspotted catshark
Schroederichthys chilensis (Guichenot, 1848)**

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Kelp forests provide feeding, reproduction and refuge habitats for multiple invertebrates and fish species. The extensive harvest of kelp from Chilean coast within the last decade is expected to affect trophic ecology of kelp associated organisms. One of the fish species frequently reported in kelp forests in Chile is the redspotted catshark *Schroederichthys chilensis* (Guichenot, 1848). We aimed to assess the effects of kelp forest cover decline on trophic ecology of redspotted catshark. This assessment was done by modelling the trophic niche of redspotted catshark based on stable isotopes of nitrogen, carbon and sulphur from four areas of the coast of Biobío region in central Chile (two with abundant kelp cover and two with majority of the kelp removed due to historical commercial harvesting). The isotopic niche space of the redspotted catshark based on proportions of three stable isotopes (nitrogen, carbon and sulphur) varied among individuals and tended to be larger in kelp depleted area, compared to its niche in areas with abundant kelp, due to more diverse carbon sources. This larger niche size might be an effect of larger home-range and movement of the shark among coastal habitats in absence of kelp cover.

Centro de Investigación en Biodiversidad y Ambientes Sustentables (CIBAS), UCSC

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Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Effect of wastewater on stream food web

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Municipal and industrial wastewaters (WW) represent an important source of pollution in aquatic ecosystems. Nowadays, it is well known that WW cause unfavourable conditions in the receiving systems. The impacts of WW are often associated with loading of nitrogen, phosphorus, hormones and psychoactive compounds. In particular, the structure and function of food chains could be strongly affected by the increased availability of nutrients. We thus, investigated effects of municipal sewage treatment plant (STP) on a stream food web, using stable isotopes analysis (SIA) of carbon and nitrogen. The stream is highly impacted by effluent from STP, which can make up approximately 25% of the water flow in the stream. The treatment processes include activated sludge mechanical-biological treatment, chemical precipitation of phosphorus without tertiary treatment. For SIA, we sampled all major food web compartments from four sites in this stream. The sites were at 2.5 km distance from each other. The first two sites were upstream of the STP and served as controls. The third site was placed 50 m downstream from STP effluent. The last site was 2.5 km further downstream to evaluate longitudinal extent of STP effect on stream food web. Our results suggest a strong impact of STP on all units of the food web of the recipient system. We found strong shifts in $\delta^{15}\text{N}$ for primary and secondary consumers in the downstream sites, suggesting substantial uptake of sewage-derived energy. Brown trout (*Salmo trutta m. fario*), the top predator of this stream, had almost two-fold value of $\delta^{15}\text{N}$ in comparison to control. Conversely, increase of $\delta^{15}\text{N}$ isotopic signal in invertebrates strongly varied across the functional feeding groups. Moreover, we found decreased species diversity in the third site. All compartments of the food web had almost similar isotopic signatures in both downstream sites. We therefore conclude that distance of 2.5 km is not enough to eliminate the effect of STP on the stream ecosystem. All these changes reflect the reliance of food web on the STP energy source. However, more investigations are needed to fill the lack of knowledge of the extent and mechanisms driving these changes.

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TJ186LL

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Resource partitioning underlies the coexistence of two sympatric cichlids in a Neotropical floodplain

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In 2005, an Amazonian cichlid (*Geophagus proximus*) was introduced in the Upper Paraná River Floodplain (UPRF), Brazil. Three years after the introduction, this fish became abundant and overcome other sympatric cichlid (*Satanoperca pappaterra*) in terms of abundance. Since both fish share similar morphological and behavior characteristics, and other studies have already reported high feeding overlap between them in reservoirs, we hypothesized that they compete by trophic resources in this environment. To test our hypothesis, we analyzed their $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ signatures in the dry and flood periods of the UPRF. We calculated the isotopic trophic ellipses (SEAc) and their overlap and tested possible significant differences (ANOVA) in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in each hydrological period to infer about trophic interactions. We found that the fishes have low isotopic overlap and they differ in regard to their $\delta^{13}\text{C}$ signatures in both hydrological periods, but not in regard to their $\delta^{15}\text{N}$ signature. This fact shows that the cichlids feed on different resources, but they are positioned in the same trophic level. Considering the isotopic niche width (SEAc), we observed that in the flood period the SEAc of *S. pappaterra* two times larger than *G. proximus*'s SEAc. In the dry period, both species showed isotopic niche width approximately three times larger than in the flood period, and also their SEAc were similar when compared to each other. According to our results, one of the processes that underlies the co-existence of these two cichlids is trophic segregation and, therefore, we rejected our hypothesis. One of the reasons for this trophic segregation might be related to the fact that *S. pappaterra* have a larger niche width in the flood period, which allows the exploitation of a wide variety of food items when they are diluted in the floodplain. Moreover, when food is scarce and concentrated (dry period), both species show a generalist potential to expand their trophic niche and explore different resources. The trophic niche does not seem to be the reason for the high abundance of the non-native species compared to *S. pappaterra* and other niche dimensions should be further investigated to elucidate this pattern.

CNPq, CAPES, Fundacao Araucaria, Nupelia/PEA/PGB

TJ485DD

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

A multi-tissue approach for a better understanding of the ecology of commercial fish species

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Understanding trophic interactions structuring ecosystem is needed to improve our knowledge of marine ecosystem functioning and to implement the Ecosystemic Approach to Fisheries. Assessing how diet varies with season or ontogeny is important to understand the ecology of species. The current resolution of the scientific surveys carried out in the English Channel and the North Sea does not allow estimating the seasonal variations of fish diet as spring and summer are not surveyed. In addition, most studies so far focused on the modal size of several species. Including individuals from the whole size range of a few species will allow here to detect ontogenic diet shift. Coupling stomach content and isotopic analyses in several tissues with different turnovers can efficiently inform past diets over different period of time. Trophic parameters from stomach contents or active tissues will inform the most recent diets, whereas muscles will record averaged value over the season. This work focuses on whiting *Merlangius merlangus*, a species with major ecological and economic interest in the English Channel, with individuals collected in autumn and winter scientific surveys. This approach will allow investigating how our perception of trophic mechanisms can be blurred by the type of tissue used. In addition, comparing the pattern observed for individuals covering the whole size range of this species will reflect how physiological status affects isotopic integration within different tissues. The collection of individuals from the commercial fishery in the seasons where no scientific surveys are operated will finally be a powerful approach to gain knowledge on the seasonal variations of trophic parameters.

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TJ761KN

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

Isotopic niche of small mammals from a neotropical savanna

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Knowing the trophic ecology of the species that occur in a given location or region allows us to understand the mechanisms responsible for their co-existence. Using carbon and nitrogen stable isotope ratios ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) and diversity metrics (SEAc) of the isotopic niche, we evaluated the trophic level of 22 small mammal species from the Central Brazilian savannas (Cerrado) through dietary contributions of three groups of food items (C_3 fruits, C_4 grasses, and invertebrates). In addition, we investigated the trophic behavior in the assimilation between dry and rainy seasons in grassland, savanna, and forest vegetation formations that occur in the Cerrado. We assessed the effects of differences in availability and diversity of food resources and of variation in habitat complexity on trophic behavior. Our results suggest that the influence of the availability and diversity of food items on the isotopic trophic niche is mediated by the own species' niche characteristics. We confirmed that omnivory is the predominant feeding category of small terrestrial mammals but certain trophic specializations were detected, such as high frugivory (C_3 source) of arboreal forest species (*R. macrurus* and *O. cleberi*) and insectivory of terrestrial swamp rats (*Oxymycterus* spp.). The amplitude of the trophic niche of some species increased in response to greater food availability, both in forest and savanna areas versus less complex areas and in the rainy season versus dry season. Moreover, the patterns of isotopic assimilation indicated that habitat-generalist species also have a broad dietary niche.

CAPES Coordenação de Aperfeiçoamento de Pessoal de Nível Superior

TS375TN

Isotope ecology from individuals to communities C

Poster presentation Thursday 2 August 2018

The historic foraging ecology of declining tufted puffin (*Fratercula cirrhata*) populations in Washington and Oregon, USA

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Tufted puffins (*Fratercula cirrhata*) are a candidate species for Endangered status in the United States due to significant population declines in WA and OR throughout the past century. Cause(s) of their decline are poorly understood but one proposed mechanism is changes in diet. To reconstruct modern and historic diets for tufted puffins in WA and OR, we conducted stable isotope analyses of carbon and nitrogen in feathers from museum specimens spanning the period 1904 to 2015. We compared $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ records of tufted puffins to those of the rhinoceros auklet (*Cerorhinca monocerata*), a closely related sympatric species that has not experienced the same severe population decline over the past century. For both species, we estimated the trophic position and use of offshore resources over time and used the SIBER model to assess their isotopic niche spaces.

There were no significant temporal changes in $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values over the past century for either tufted puffins or rhinoceros auklets, suggesting that both of these species have had consistent spatial feeding habits and trophic positions through time. Our results are in contrast to those from similar studies that examined the historic diets of declining populations of marbled murrelets and glaucous-winged gulls and reported significant decreases in $\delta^{15}\text{N}$ values and significant changes in $\delta^{13}\text{C}$ values over time, respectively. Although tufted puffins and rhinoceros auklets have sympatric breeding colonies, our results suggest that they have different spatial foraging patterns; tufted puffin $\delta^{13}\text{C}$ values indicate use of pelagic resources (range -20.5 to -17.1‰), while the wider range in rhinoceros auklet $\delta^{13}\text{C}$ values indicates use of coastal and pelagic resources (range -18.7 to -14.1‰). In comparison, the $\delta^{15}\text{N}$ values of both species were similar (tufted puffin: 13.8 to 19.4‰; rhinoceros auklet: 14.9 to 19.4‰), which could imply extensive trophic overlap. Although these results imply that tufted puffin populations in WA and OR have not experienced a dietary shift over the last century, these birds could be restricted to foraging on pelagic resources and could therefore be more sensitive to changes in prey availability in their narrower spatial foraging range while rhinoceros auklets could have more foraging flexibility across habitats.

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CH511MB

New methods and models in isotope ecology

Poster presentation Thursday 2 August 2018

Oxygen and hydrogen isotope geochemistry of thermal springs in the northern part of eastern Algeria

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This study deals with the results of a hydrochemical and geothermal study of thermal waters in northeastern Algeria. Eleven samples were collected during the period between November 2013 and April 2015. To identify the origin of the thermal groundwater and for the evaluation of the reservoir temperature in the geothermal systems, the following data were used: concentrations of major chemical constituents, stable isotope ratios (δD and $\delta^{18}O$), saturation indices and chemical geothermometer temperatures. The physicochemical parameters (temperature, pH, and electric conductivity) were measured in-situ; the temperature of the thermal water samples varied from 38 to 96°C, the pH value of these springs is slightly acid to neutral, with high electrical conductivities up to 4500 $\mu S/Cm$. Piper diagrams highlighted two major hydrochemical facies namely sodium chloride (Na-Cl) and sodium sulfate (Na-SO₄). The mineral composition of the thermal waters reflects the geological formations found in the deep origin reservoir and chemical changes in the fluids were highly influenced by water-rock interaction. The thermal waters from the study area are depleted in ¹⁸O and D and plot on the global meteoric water line (GMWL), their deep-circulating meteoric origin shows that most thermal waters plot on or near the meteoric water line, with some exceptions due to Mediterranean precipitation, probable water-rock isotope exchange or mixing takes place between the ascending geothermal water and shallow colder groundwater. The subsurface reservoir temperatures were calculated using different solute geothermometers and computation of saturation indices for different solid phases. The highest estimated reservoir temperatures are indicated by the cation composition geothermometer (CCG) and the Na-K-Ca geothermometer, while slightly lower estimates are obtained using silica geothermometers, with local geothermal gradients ranging from 25 to 45 °C/km.

DN936LT

New methods and models in isotope ecology

Poster presentation Thursday 2 August 2018

Trophic position in two sympatric amphipods determined from nitrogen isotopic composition of amino acids

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In benthic environments, two distinct trophic pathways are common: one based on the utilization of sedimented phytodetritus by surface-deposit feeders and another relying on aged organic matter consumed by sub-surface feeders. The analysis of nitrogen isotopic composition of amino acids (AA-SIA) can be used to estimate the degree to which organic matter was re-worked by microorganisms within the sediment before the assimilation by the animals. This information is valuable for comparison of trophic position between species with different feeding modes. We applied AA-SIA to estimate trophic position in two sympatric amphipods, *Monoporeia affinis* and *Pontoporeia femorata*, inhabiting soft bottom sediments in the Baltic Sea. Interspecific competition between the species results are known to result in spatial niche partitioning by depth in the sediment, with *P. femorata* burying deeper down and feeding on older organic matter, which results in lower growth rates. We found large variability in trophic position within species. We discuss our AA-SIA results in relation to environmental conditions and physiological status.

FG396LF

New methods and models in isotope ecology

Poster presentation Thursday 2 August 2018

Comparing statistical methods for the estimation of trophic enrichment factors

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Stable isotope mixing models (SIMMs) are an important tool used to study species' trophic ecology. However, these models are dependent on, and sensitive to, the choice of trophic discrimination factors (TDF). Ideally, controlled feeding trials should be conducted to determine the appropriate TDF for each consumer, tissue type, food source, and isotope combination. However, in reality this is often not feasible nor practical and hence requires the estimation of TDF values from available knowledge and data. These estimation methods include using the mean TDF of a taxonomic group; using the closest related species with experimentally measured TDF values; using mean estimates from regression models; or using imputed species-specific values from regression models in the Bayesian framework of the recent *SIDER* package. Here we compare the ability of each of these methods to estimate TDF values using a dataset of 409 observations of nitrogen and carbon TDFs for birds and mammals. We find that while estimates from *SIDER* are typically associated with large uncertainties, they were more accurate than each of the other tested approaches. We explore how to reduce the large uncertainties associated with *SIDER* estimates through developing more appropriate regression models that incorporate the sources of variation in TDF values relating to ecological and physiology factors. Finally, We explore the potential of alternative models of evolution and the use of ancestral state reconstruction for estimating TDF values. By developing models which better capture the processes driving variation in TDFs, these approaches may lead to more accurate estimates of TDFs with more appropriate uncertainties associated with them. While feeding trails are the gold standard to estimate TDF values, these methods will bridge the gap for species which have not yet been experimentally measured or for species for which such feeding trails are not feasible.

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Lipid corrections in carbon and nitrogen stable isotope analyses in freshwater fishes of the Paraná river, Argentina.

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Stable isotope analysis (SIA) coupled with mixing models are powerful tool for examining diet and food-web dynamics in aquatic ecosystems. Nitrogen isotopes can be used to determine trophic position, increasing about 3-4‰ at each trophic level. Carbon stable isotopes can be used to trace energy sources in food webs, because isotope values increase only slightly between diet and consumer (0–1‰) during trophic transfers. Within an organism, lipids are depleted in ¹³C relative to proteins and carbohydrates, and variation in lipid content between species has the potential to increase variability in δ¹³C values. Despite the potential for introduced error, there is no consensus on the need to account for lipids in SIA. Several studies recommend accounting for lipids through chemical extraction prior to SIA or mathematical normalization when the lipid content in sample tissue is high (i.e., C:N >3.5, lipid content >5%) in fish muscle. While normalization models have been tested for some aquatic organisms, there has been no investigation of freshwater fauna of the Paraná river, the second largest river in South America. In this study, effects of lipid extraction and mathematical correction methods for eight freshwater fishes were compared to better understand impacts of normalization approaches on carbon (δ¹³C) and nitrogen (δ¹⁵N) stable isotope data. Following Sweeting lipid extraction, δ¹³C values were higher for all species with a mean increase of 0.36 ± 0.23‰. In contrast, there was a mean decrease in δ¹⁵N of 0.42 ± 0.37. The lipid content ranged from 3.1% to 5.5% for *Leporinus obtusidens* and *Cyphocharax voga*, respectively. Only for *C. voga* the C:N >3.5 before treatment, extraction resulted in a decrease in C:N ratio and changes up to 1‰ in δ¹³C. For this species similar values of δ¹³C lipid-free were obtain using previous normalization models. The best fit relationship for δ¹³C was $\delta^{13}\text{C}_{\text{lipid-free}} = 0.88 \times \delta^{13}\text{C}_{\text{bulk}} - 3.00$ (R²=0.97; p<0.001).

HH882PH

New methods and models in isotope ecology

Poster presentation Thursday 2 August 2018

Evapotranspiration partitioning using isotope-based approaches

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Evapotranspiration accounts for about 65% of the precipitation input at a global scale and this number can be up to 95% in dry environments. Partitioning evapotranspiration into transpiration (vegetation-controlled processes) and evaporation (physical-controlled processes) is important for quantifying the water budget and understanding vegetation control on water cycles in various ecosystems. How vegetation responds to future environmental change poses one of the largest uncertainties in climate model predictions. With the development of spectroscopy-based techniques for in-situ isotope measurements, the use of stable isotope-based evapotranspiration partitioning is rising. In this study, I discuss the uncertainties in evapotranspiration partitioning, the needs and advantage of isotope-based evapotranspiration partitioning and provide examples to partition evapotranspiration at different systems using isotope-based approaches. This synthesis demonstrates the advantages and limitations of using isotopes to partition evapotranspiration across scales.

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KK891NH

New methods and models in isotope ecology

Poster presentation Thursday 2 August 2018

Calibration, error estimation, and quality assurance of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ measurements from individual amino acids

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Across the last decade, promising applications of compound-specific stable isotope analysis of individual amino acids (CSIA-AA) have developed rapidly, particularly within organismal ecology. As in the early days of bulk stable isotope analysis (BSIA), the establishment of best practices to facilitate the reproducibility of CSIA-AA measurements has lagged behind the rush to applications. Primary concerns include accounting for (1) the diversity of techniques for the derivatization of amino acids prior to analysis by gas chromatography/combustion/isotope-ratio mass spectrometry (GC/C/IRMS) and (2) the impact of exogenous carbon on $\delta^{13}\text{C}$ measurements, especially when combined with the myriad of standardization practices and quality assurance procedures used across studies.

Here we demonstrate the impact that differences in normalization procedures can have on the accuracy and precision of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ amino acid measurements by GC/C/IRMS, as well as the essential value of appropriate reference materials to assess the quality of the applied calibration procedures. We also provide a review of the calibration procedures required to account for exogenous carbon in $\delta^{13}\text{C}$ measurements and demonstrate the influence of these procedures in error estimation and propagation. By adopting calibration procedures and quality assurance protocols that mirror those from BSIA, we were able to significantly improve reproducibility in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ measurements of individual amino acids across different derivatives with differing amounts of exogenous carbon. Standardized calibration and quality assessment practices will be important to establishing reproducibility in CSIA-AA measurements, both within and among laboratories. It is both technically practical and desirable for CSIA-AA to adopt practices in quality control and assessment similar to those outlined for BSIA, to improve not only accuracy and precision, but also long-term reproducibility. Improved reproducibility will aid in the evaluation of data across studies and help to expedite the advancement of CSIA-AA applications in organismal ecology.

KL915ND

New methods and models in isotope ecology

Poster presentation Thursday 2 August 2018

Ecodiet: a bayesian model to integrate data from the literature, stomach contents and isotopes to improve diet estimates

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Over the past decades, stable isotopes analyses (SIA) have become a standard tool in feeding ecology and Bayesian stable isotopes mixing models (SIMMs) have been developed to estimate dietary proportions of a consumer from its isotopic signature and that of its preys. However, the use of SIMMS suffers one main limitation: the ability to estimate sources contributions drastically declines with increasing number of potential sources. This is particularly problematical while studying complex systems characterized by high species diversity and low interspecific isotopic variability (e.g. large open marine ecosystems). Therefore, defining accurate topological structure of the food-web is a prerequisite for applying SIMMs to real case study. In this paper, we provide a Bayesian integrated modelling approach, EcoDiet, that allows for integrating multiple sources of information from the literature and from local data to simultaneously estimate the topological structure of the food web and the diet composition. Specifically, this approach: (i) considers *a priori* knowledge from the literature on both topology and dietary proportions (ii) determines the topological web from the prior information and frequencies of occurrence of preys found in the stomach content analysis (SCA) (iii) estimates the dietary proportions of all the consumers in the ecosystem through a SIMM using both prior information and isotopic data. As a test, the EcoDiet model was applied to the Celtic Sea, a North-west European ecosystem. We showed how combining the multiple sources of data within an integrated approach provides a more accurate and simpler topological food web structure than literature alone. This allows more robust and realistic diet estimates compared to simple SIMMs. Integration of SCA allowed discrimination between prey with similar isotopic signatures while classical SIMMs estimated equal contributions. Inclusion of literature information compensated the snapshot vision of SCA, authorizing contributions for species unobserved in stomachs but known as substantial preys and detectable in the more integrative SIA. Finally, EcoDiet appears a general new tool with the potential to improve the understanding of prey-predators interactions and has the potential to become the reference method for building diet matrix in trophic models such as Ecopath. IFREMER/Region Bretagne

PF393SM

New methods and models in isotope ecology

Poster presentation Thursday 2 August 2018

Temporal records of diet diversity dynamics in individual adult female Steller sea lion (*Eumetopias jubatus*) vibrissae

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Detailed information on the nutrition of free-ranging mammals contributes to the understanding of life history requirements, yet is often quite limited temporally for most species. Reliable dietary inferences can be made by analyzing the stable carbon (C) and nitrogen (N) isotopic values ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) of some consumer tissues; exactly which tissue is utilized dictates the inferential scope. Steller sea lion (SSL) vibrissae are grown continuously without shedding and thus provide a continuous multi-year record of dietary consumption. We applied a novel kernel density approach to compare the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values along the length of SSL vibrissae with $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ distributions of potential prey species. This resulted in time-series of proportional estimates of dietary consumption for individual SSL. Substantial overlap in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ distributions for prey species prevented a discrete species-scale assessment of SSL diets; however, a *post-hoc* correlational analysis of proportional estimates revealed grouping by trophic level. Our findings suggest that adult female SSL diets in the western and central Aleutian Islands shift significantly according to season: diets contain a higher proportion of lower trophic level species (Pacific Ocean perch, northern rockfish, Atka mackerel and walleye pollock) in the summer, whereas in the winter SSL consume a much more diverse diet which includes a greater proportion of higher trophic level species (arrowtooth flounder, Kamchatka flounder, darkfin sculpin, Pacific cod, Pacific octopus, rock sole, snailfish, and yellow Irish lord).

TC315MQ

New methods and models in isotope ecology

Poster presentation Thursday 2 August 2018

Method development and applications of N₂ and N₂O measurements in water and gas samples on a GasBench II

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Over the last two years we have been developing methods to analyse N₂ and N₂O in water and gas samples to support research investigating nitrogen cycle pathways. A GasBench II linked to a Delta V Plus isotope ratio mass spectrometer (IRMS) (Thermo Fisher Scientific, Germany) enables us to measure isotope ratios of ¹⁵N/¹⁴N of N₂, plus ¹⁵N/¹⁴N and ¹⁸O/¹⁶O of N₂O, in natural abundance or enriched water or gas samples. We have modified methods in the literature to produce optimal conditions for accurate and precise N₂ and N₂O measurements, and here present details of our analytical set-up and quality control reporting parameters. Two case studies are presented: the first used enriched N₂ in waste water experiments to understand the processes that remove nitrogen in domestic waste water treatment plants. The aim was to establish how effective the treatment filters are in these systems. The second study, measured N₂ concentrations and N isotope ratios in soil experiments to quantify the amount of N₂ formed via biological (denitrification, codenitrification, anammox) and chemical pathways in soil. The objective of the project was to establish a new cost-effective mechanism of chemically converting reactive nitrogen (N₂) common in soil, and then to remove it, before it could turn into harmful N₂O greenhouse gas. The ultimate aim of the project, was to mitigate and reduce N₂O emissions in grazed agricultural systems.

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