6TH INTERNATIONAL JELLYFISH BLOOMS SYMPOSIUM

Book of Abstracts

4 - 6 NOVEMBER 2019

IZIKO SOUTH AFRICAN MUSEUM | CAPE TOWN | SOUTH AFRICA

PHOTO CREDIT: @Steven Benjamin
ORGANISERS
University of the Western Cape, Cape Town, South Africa

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Mark J Gibbons (University of the Western Cape)
Delphine Thibault (Aix-Marseille Université)
Wayne Florence (IZIKO South African Museum)
Maryke Masson (Two Oceans Aquarium)

INTERNATIONAL STEERING COMMITTEE, ISC
Mark J Gibbons (Africa)
Agustin Schiariti (South America)
Lucas Brotz (North America)
Jing Dong (Asia)
Jamileh Javidpour (Europe)
Delphine Thibault (Wandering)
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Message from the Convenor:  

_Prof Mark Gibbons_

On behalf of the Local Organising Committee, it gives me great pleasure to welcome you to Cape Town and to the 6th International Jellyfish Blooms Symposium. It promises to be a suitable finale to Series I, which has seen us visit all continents except Antarctica. Episode One kicked off in North America during January 2000, when Monty Graham and Jennifer Purcell invited us to Gulf Shores. Seven years later Kylie Pitt dragged us off to the Gold Coast in Australasia for episode Two, and our late, and much beloved, colleague Hermes Mianzan introduced us to the delights of a cold and wet Mar del Plata in South America some three years later. In 2013, Shin-Ichi Uye welcomed us to Asia by hosting episode Four in Hiroshima and Europe’s turn came in 2016, when Verónica Fuentes and her team seduced us in a visit to Barcelona.

Episode Six takes us to the cradle of humankind, thereby returning us to the polyp. Polyps can develop in a myriad of ways, and we have tried to emphasise development in our programme and associated events. A student at the Red and Yellow Creative School of Business has designed our logo, and a student jazz band from the University of the Western Cape (UWC) will provide our entertainment at the gala dinner. We have deliberately collaborated with the Creative Design Institute to provide local entrepreneurs with an opportunity to develop conference-themed items for retail, and we encourage you to both support their imagination and spread the word. Our conference bags, generously sponsored by De Beers, are made by local communities using locally sourced, in part recycled, materials: if you have purchased a T-shirt, it too is manufactured locally using locally sourced recycled plastics. Our organisational partners are Iziko Museums of South Africa and the Two Oceans Aquarium, and both organisations have capitalised on the meeting in various outreach activities with the broader public. Spreading our science beyond the academy is important in a developing country like ours, and we would urge future meetings to engage similarly with their communities.
But we are here for the science, and the science programme is a packed one, with almost 150 presentations delivered by participants from 25 countries and all continents, except Antarctica. We have representatives from six African countries, thanks to generous help from the South African National Research Foundation. We are especially pleased to see so many students (almost 50) and we are grateful to all the PIs that have had to make sacrifices in order to allow their mentees to participate.

In Barcelona, when Monty Graham twisted my arm to agree to host the sixth meeting, I implied that lions walked the streets of the city – this is Africa after all! I am sorry but I lied, and the last lion seen wandering around Cape Town was shot in 1802: though leopards are regularly seen not 60 km away. Although I didn't lie about the uncertainty and chaos that we are facing in the world today, I am hoping that you will forget about it for the next three days and immerse yourselves in the science of jellyfish and the people that share your passion. And of course, that you will find the time to, carefully, enjoy the splendour and serenity of Cape Town.

Welcome.
The southern tip of the African continent is the meeting place of two mighty and bountiful oceans, the Indian and the Atlantic. The Two Oceans Aquarium on the V&A Waterfront, Cape Town is ideally positioned to showcase the incredible diversity of marine life found in these two oceans. The Aquarium's exhibits and displays have an educational focus, providing access to this unique natural world to more than 500 000 visitors per year, from near and far.

In addition to being an award-winning attraction, the Aquarium is also deeply invested in environmental education and campaigning, conservation, and research. In 2018 the Two Oceans Aquarium Education Foundation was established as a registered Non-Profit Organisation with Public Benefit status, making possible the expansion of its education, conservation and research programmes.

We welcome the International Jellyfish Blooms community to Cape Town and the Two Oceans Aquarium, and we wish you a successful, informative, productive and enjoyable symposium.

Sea you at the Aquarium.
The University of the Western Cape (UWC) has trod a long and winding road, from a “Bush college” offering limited training for Coloured people, to become a cornerstone of the post-1994 South Africa, and one of Africa’s finest higher education institutions.

UWC was established in 1959 in terms of the extension of Higher Education Act of 1956 as a University College for “non-whites other than Bantu”. Rejecting these ideological foundations, it became the home of the anti-apartheid left and a large part of the leadership of the new South Africa originated from UWC. Relevant research from the University informed early policy development and the University continues to be at the forefront of intellectual debate and transition, producing new generations of researchers and graduates to provide leadership for their communities, and their world.

In the face of global climate change, poverty, inequality and the clash of cultures, UWC sees itself as an engaged university - a nexus of research, teaching and learning that responds to the needs of a society in transition in critical and creative ways. The University is committed to being a research-led learning-focused university that acts as an anchor institution in the region, connecting communities, industries and academics: it strives to be a hub in the research and innovation landscape as well as a place with a sense of community, where collective leadership matters.

Drawing on its proud experience in the liberation struggle, the University is committed to a distinctive academic role in helping to build an equitable and dynamic society.
Discover
South Africa’s unique history and heritage. Explore Iziko Museums of South Africa, and connect with a rich tapestry of diverse narratives.

Visit any of our 11 national museums in Cape Town, and be inspired by exciting exhibitions, objects, artefacts and artworks.

See opening hours, entrance fees and more information online
Tel. 021 481 3800 • email info@iziko.org.za

www.facebook.com/IzikoMuseums
@Iziko_Museums
## OPENING CEREMONY

**TWO OCEANS AQUARIUM**  
**DOCK ROAD AT THE V&A WATERFRONT**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
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<tbody>
<tr>
<td>18:30</td>
<td>Registration of participants, collection of the conference bags, and the conference T-shirts will be located next to Nemos' tank, follow the posted signs. (Remember to upload your presentation if yours is scheduled on Monday morning). Walk to the Predators exhibits, follow the posted signs. Grab a glass of local beer, red or white wine or a cold drink, some local delicacies and chill while watching the sharks. (2 drinks are offered by the symposium + cash bar available on site).</td>
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<tr>
<td>19:15</td>
<td>Welcome on behalf of LOC by Delphine Thibault</td>
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<td>19:20</td>
<td>Opening address by the Deputy Vice Chancellor (Academic) – Prof. Vivienne Lawack – University of the Western Cape</td>
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<td>19:25</td>
<td>Welcome on behalf of Two Oceans Aquarium by Maryke Musson, Curator</td>
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<td>19:28</td>
<td>Closing address by Mark J Gibbons</td>
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<td>19:30 - 20:00</td>
<td>“The Institute of Jellyfish” performance</td>
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<td>22:00</td>
<td>End of the party</td>
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The Institute of Jellyfish, consisting of the cultural scientists and media artists Dr. Kathrin Dreckmann and Dr. Verena Meis, sees itself as an elastic and transparent institution which pulsates between science, media and art. With its new research line, the Institute pursues the objective to create an awareness for interdisciplinary approach and aesthetic ecology.

As a media figure of thought and movement, the jellyfish is used as an ocular to direct the gaze via and through the animal to the human, its body and to its environment. Therefore, the lecture, sound and video performance follow diverse aesthetic figurations in which jellyfish appear with visionary power concerning environment, gender and material.

For more information please visit http://qualleninstitut.de/
### Monday 4 November 2019

<table>
<thead>
<tr>
<th>Time</th>
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<tr>
<td>08:00 - 09:00</td>
<td>Welcome desk</td>
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<tr>
<td>09:00 - 09:15</td>
<td>Welcome talk + CEO Iziko</td>
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</table>
| 09:15 - 10:40 | **Session IBJS6-00**  
**General**  
Conveners: Verena Ras, Zafrir Kuplik  
Jellyfish blooms along the southwest coast of India: Current status and trends - *Riyas Abdul*  
Phylogenetic relationships within the order Coronatae (Coronatae; Scyphozoa), with emphasis on genus *Nausithoe* Köllicker, 1853-*Clarissa Garbi Molinari*  
Hydrozoan pelagic diversity in Norway (HYPNO) - project summary and selected results - *Aino Hosia*  
Mega-swarm of northern sea nettles (*Chrysaora melanaster*) in the Gulf of Alaska in the winter of 2019 - *Evgeny Pakhomov*  
Long-term changes in gelatinous zooplankton diversity and distribution in the Atlantic Gateway to the Arctic - *Maciej Manko*  
Sexual reproduction in *Acraspeda* (Medusozoa, Cnidaria): a morpho-evolutionary approach - *Gisele R. Tiseo*  
*Chrysaora fulgida*: adaptations to life in an upwelling system - *Heidi Skrypzeck* |
| 10:40 - 11:00 | COFFEE BREAK                                                        |
| 11:00 - 11:40 | Three-dimensional ecological niche modelling of midwater jellyfish: project outlook - *Gerlien Verhaegen*  
The effect of temperature and food availability on the asexual reproduction of *Aurelia aurita* and *Cyanea capillata* - *Amanda Wiesenthal*  
Coastal acidification does not exacerbate effects of hypoxia on the settlement and swimming behaviour of creeping polyps of the Irukandji jellyfish, *Alatina alata* - *Sheldon Rey Boco* |
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<tr>
<th>Time</th>
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<tr>
<td>11:40 - 12:40</td>
<td>Poster speed presentations #1</td>
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<tr>
<td>12:40 - 14:00</td>
<td>LUNCH</td>
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| 14:00 - 14:55| Transparent world: Siphonophores made of glass - Götz-Bodo Reinicke  
Ernst Haeckel's mysterious cubomedusan species - Ilka Straehler-Pohl  
Jellyfish mucus as a means to combat plastic pollution? - Hila Dror  
Microplastics ingestion does not harm moon jellyfish's fitness - Phuping Sucharitakul |
| 14:55 - 15:40| Poster speed presentations #2                |
| 15:40 - 16:00| COFFEE BREAK                                |
| 16:00 - 16:40| A project of jellyfish disaster prevention for the nuclear power plant in China - Chaolun Li  
Comparative transcriptomic identification of venom proteins in the clinging jellyfish Gonionemus vertens - Alorah Bliese  
Spatiotemporal distributional pattern of Nemopilema nomurai monitored using sighting, trawl net and plankton net in Yellow Sea and Liaodong Bay of Bohai Sea during 2017-2019 - Jing Dong  
Recent changes in the phenology of Scyphozoans in the southwestern Mediterranean Sea - Mohamed Najib Daly Yahia |
| 17:00 - 18:00| Poster speed presentations #3                |
| 18:00 - 19:30| POSTERS SESSION                            |
**Tuesday 5 November 2019**

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<thead>
<tr>
<th>Time</th>
<th>Session IBJS6-01</th>
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<tbody>
<tr>
<td>08:00 - 08:30</td>
<td>Welcome desk</td>
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<tr>
<td>08:30 - 10:40</td>
<td>THE CRYPTIC AND INTEGRATIVE ECOLOGY OF MEDUSAE AND POLYPS Conveners: Michael N Dawson, Cheryl Ames, Basant Bentlage, Agustin Schiariti, André Morandini</td>
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**Opening talk**

**Distribution of polyps of *Aurelia coerulea*: strong evidence of anthropogenic causation of the jellyfish blooms**
- *Jinho Chae*

**Aurelia aurita** polyp response to simulated marine heatwaves - *Vanesa Romero Kutzner*

Will *Cotylorhiza tuberculata* populations increase under future Mediterranean acidification and temperature conditions?  
- *Angélica Enrique-Navarro*

Hyposalinity and incremental micro-zooplankton supply in early-developed *Nemopilema nomurai* polyp survival, growth, and podocyst reproduction  
- *Song Feng*

Seasonal dimorphism in the ontogenetic development of moon jellyfish *Aurelia coerulea* and the contribution of the direct-development life cycle type to the population dynamics in Maizuru Bay, Japan  
- *Kentaro Suzuki*

Backtracking a bloom: where to find the scyphopolyps?  
- *Nicole Aberle*

Transgenerational effects facilitate acclimation to a varying climate in *Aurelia aurita* polyps - *Alexandra Loveridge*

The Ellis Island effect: invasive Hydrozoans in the Mid-Atlantic  
- *Paul Bologna*

Molecular phylogeny of the upside-down jellyfishes (Rhizostomeae: Cassiopideae: *Cassiopea*): implications on their origin and diversification - *Edgar Gamero-Mora*

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<th>COFFEE BREAK</th>
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<tr>
<td>11:00 - 12:40</td>
<td>Morphological overlap hinders diagnosability: recognizing cryptic diversity in <em>Aurelia</em> (Cnidaria, Scyphozoa) - Jonathan W. Lawley</td>
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<td>The effect of temperature on embryonic development and planulæ settlement of <em>Nemopilema nomurai</em> - Yan Duan</td>
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<td>Transgenerational effects of temperature influence asexual reproduction in scyphistomæ of the bloom-forming and invasive jellyfish <em>Aurelia aurita</em> - Cathy Lucas</td>
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<td>The recovery after the damage: chronic exposure of polyps to a cocktail of pesticides has no effect on ephyrae - Carolina Olguin Jacobson</td>
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<td>Experimental evidence that statolith elemental chemistry can elucidate the movements of an elusive Hawaiian cubozoan - Scott Morrissey</td>
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<td>An integrative approach for the assessment of diversity and distribution of polyps and their medusæ in Norwegian waters - Luis Martell</td>
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<td><em>Rhizostoma luteum</em>; a large jellyfish to be rediscovered - Karen Kiensberger</td>
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<tr>
<td>12:40 - 14:00</td>
<td>LUNCH</td>
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<tr>
<td>14:00 - 14:40</td>
<td>Sunbathing Jellies: What do we know of Zooxanthellate Jellyfishes? - Nicolas Djeghri</td>
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<td>The macroecology of the megamedusæ - Michael Dawson</td>
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<td>The evolutionarily conserved molecular dynamics of strobilation - Rebecca Helm</td>
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<td>Session IBJS6-02 ROLE OF JELLYFISH IN ECOSYSTEM STRUCTURE AND FUNCTION: FROM PREDATOR-PREY INTERACTIONS TO BIOGEOCHEMICAL CYCLING</td>
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<td>Conveners: Cathy Lucas, Tom Doyle, Jonathan Houghton, Nathan Hubot</td>
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<td>Opening talk</td>
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<td>Resilience of <em>Aurelia aurita</em> to zooplankton regime shifts - Amanda Wiesenthal</td>
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<td>The trophic ecology of <em>Aurelia coerulea</em> in a Mediterranean coastal lagoon - Raquel Fonseca da Silva Marques</td>
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<tr>
<td>Time</td>
<td>Session Content</td>
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</tbody>
</table>
| 14:40 - 15:40     | Tiny jellies, big appetite: Population dynamics of hydromedusae in North Inlet Estuary, SC, USA, and their role in regulating estuarine food webs - *Joshua Stone*  
Predatory babies: the potential of *Pelagia noctiluca* ephyrae feeding on larval tuna - *Daniel Ottmann*  
Predation selection and diet of jellyfish *Cyanea nozakii* in the northern East China - *Pengpeng Wang* |
| 15:40 - 16:00     | **COFFEE BREAK**                                                                                                                                 |
| 16:00 - 18:00     | Marine endotherms as global predators of jellyfish: from "junk food" to "green tea" hypotheses - *Jean-Baptiste Thiebot*  
Ontogenetic shifts in ocean sunfish diet - *Jonathan Houghton*  
Have sunfish benefited from the ‘rise of slime’? - *Tom Doyle*  
Large vertical migrations of *Pyrosoma atlanticum* play an important role in active carbon transport - *Natasha Henschke*  
Respiratory metabolism analysis in *Aurelia aurita* and *Pelagia noctiluca* - *Daniel R. Bondyale Juez*  
Evidence of nitrification associated with jellyfish - *Nathan Hubot*  
Respiration rates, metabolic demands and feeding of the rhizostome *Rhopilema nomadica* - *Zafrir Kuplik*  
Trophic enrichment factors and tissue turnover rates for δ¹³C and δ¹⁵N in *Aurelia aurita* - *Jessica Schaub*  
Exploring the diversity of microbiota associated with moon jellyfish mucus - *Valentina Turk*  
Concluding remarks |
| 18:00 - 19:30     | **POSTERS SESSION**                                                                                                                                 |
### Wednesday 6 November 2019

<table>
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<tbody>
<tr>
<td>08:00 - 08:30</td>
<td>Welcome desk</td>
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| 08:30 - 10:40 | **Session IBJS6-03**  
THE HUMAN-JELLYFISH NEXUS  
Conveners: Rachel Tiller, Angel Yanagihara, Jamileh Javidpour, Angus Bloomfield, Lucas Brotz  

Pest and plague or valuable resource and opportunities:  
Stakeholder perceptions of Jellyfish across Europe - **Rachel Tiller**  

The cnidome of *Pelagia noctiluca* (Forsskål, 1775) and why you should not use vinegar in case of its sting - **Ainara Ballesteros**  

Protective effect of epigallocatechin-3-gallate (EGCG) on toxic metalloproteinases-mediated skin damage induced by Scyphozoan jellyfish envenomation - **Eulkyung Kim**  

Jellyfish venom extraction and delivery in animal models; do we have it right? - **Jamie Seymour**  

Preliminary studies to improve outcomes of box jellyfish sting injuries in the Indo-Pacific - **Angel Yanagihara**  

Jellyfish blooms in India: Ecosystem implications and socio-economic concerns - **Biju Kumar Appukuttannair**  

The race for jellyfish: winners and losers in Mexico's Gulf of California - **Lucas Brotz**  

Interactions between jellyfish and finfish aquaculture: current mitigation strategies - **Damien Haberlin**  

MedusApp, a citizen science tool for monitoring jellyfish populations and stings - **Cesar Bordehore**  

Towards an early warning system for jellyfish blooms - **Angus Bloomfield**  

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<tr>
<th>10:40 - 11:00</th>
<th>COFFEE BREAK</th>
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| 11:00 - 12:40 | More than 10 years dealing with jellyfish blooms: the Jellyfish Observation Network in the NW Mediterranean - **Macarena Marambio Campos**  
Progress on the disaster prevention & mitigation strategy, equipment development for emergency disposal of Jellyfish Bloom in China coastal waters - **Zhang Fang** |
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<tr>
<th>Time</th>
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<tr>
<td>11:00 - 12:40</td>
<td>Precautionary management of jellyfish bloom by polyp elimination</td>
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<td><em>Sunwoo Kim</em></td>
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<td>The microstructure of jellyfish mesoglea and jellyfish chips</td>
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<td><em>Mathias Clausen</em></td>
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<td>Are farmed fish hungry for jellyfish? - The potential of jellyfish as</td>
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<td>alternative source of proteins in fish feed - <em>Tjaša Kogovšek</em></td>
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<td>Biotechnological applications of scyphomedusae</td>
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<td><em>Isabella D’Ambra</em></td>
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<td>Sea Jellies Illuminated: Partnering with Sea World to deliver a</td>
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<td>state-of-the-art jellyfish research laboratory that engages the public</td>
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<td>in jellyfish science - <em>Kyle Pitt</em></td>
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<td>12:40 - 14:00</td>
<td>LUNCH</td>
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<td>14:00 - 15:40</td>
<td>Session IBJS6-04</td>
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<td>NOVEL TECHNIQUES FOR UNDERSTANDING THE ECOLOGY OF GELATINOUS ZOOPLANKTON</td>
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<td>BLOOMS</td>
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<td>*Conveners: Dror Angel, Natasha Henschke, Mary Beth Decker, Evgeny A.</td>
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<td>Pakhomov, Cornelia Jaspers*</td>
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<tr>
<td></td>
<td>Opening talk</td>
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<td>How do we quantify the abundances of something as elusive as jellyfish?</td>
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<td><em>Dror Angel</em></td>
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<td><em>Chrysaora melanaster</em> spatial and seasonal dynamics detected by</td>
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<td>Adaptive Resolution Imaging Sonar (ARIS) in the eastern Bering Sea</td>
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<td><em>Mary Beth Decker</em></td>
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<td>Detection of the cubozoan, <em>Copula sivickisi</em>, using environmental DNA</td>
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<td>(eDNA) - <em>Brett Bolte</em></td>
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<td>A novel platform for monitoring small gelatinous zooplankton: the</td>
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<td>high-speed Gulf VII plankton sampler captures gelatinous mesozooplankton</td>
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<td>as effectively as a traditional ring net - <em>Aidan Long</em></td>
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<td>Combining UAVs and AI: producing an early warning system for coastal</td>
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<td>industries - <em>Ben Mcilwaine</em></td>
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<td>State-of-the-art technologies to study <em>Pelagia noctiluca</em> in the</td>
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<td>Balearic Sea (Mediterranean Sea) - <em>Laura Prieto</em></td>
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<td>Spatial shifts of major gelatinous and crustacean metazoans in</td>
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<td>response to projected climate change scenarios - <em>Evgeny Pakhomov</em></td>
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<tr>
<td>Time</td>
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<tr>
<td>15:40 - 16:00</td>
<td>COFFEE BREAK</td>
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</table>
| 16:00 - 17:40| Is phenotypic plasticity determined by temperature and fluid regime in scyphomedusae? - *Mayara de Almeida Jordano*  
*Pelagia noctiluca* ephyrae from NW Mediterranean Sea: where are they before becoming medusae? - *Marina Pastor*  
Ecology and population connectivity of the cubozoan *Copula sivickisi* in northern Australia - *Michael Kingsford*  
Population structuring of *Chrysaora africana* and *Chrysaora fulgida* across the west coast of Africa - *Verena Ras*  
Causes and consequences of the great pyrosome bloom in the Northern California Current - *Richard Brodeur*  
Modeling *Pelagia noctiluca* dynamics in the Mediterranean Sea - *Léo Berline*  
Using citizen science, at-sea observations and a Lagrangian particle-tracking model to determine the source of a Portuguese Man O'War *Physalia physalis* (Hydrozoa: Siphonophorae) mass stranding event - *Jasmine L. Headlam*  
Quorum sensing and abiotic factors underlying bloom potential in *Mnemiopsis*: new evidence from laboratory culture - *Joan Josep Soto Angel*  
Concluding remarks |
<p>| 19:00 - 23:00| AWARDS AND FAREWELL AT THE TWO OCEANS AQUARIUM |</p>
<table>
<thead>
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<th>Session IJBS6-00</th>
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<td>Effects of temperature shifts on strobilation - <em>Schiariti</em></td>
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<td>A needle in a haystack: an integrative approach for identifying the ecology of the Irukandji - <em>Seymour</em></td>
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<td>Implications of <em>Pyrosoma atlanticum</em> grazing on phytoplankton standing stocks in the Northern California Current - <em>Bernard</em></td>
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<td>Trophic interactions between <em>Pelagia noctiluca</em> and plankton in the Gulf of Naples (Tyrrenian Sea, Central Mediterranean) - <em>Merquiol</em></td>
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<td>Influence of jelly-falls and aquaculture organic discharges on benthic ecosystem processes - <em>Sweetman</em></td>
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<td>Prevalence, abundance and intensity of infection of a new species of parasitic sea anemone from <em>Chrysaora kynthia</em> (Cnidaria: Scyphozoa) - <em>Pitt</em></td>
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<td>Identification of pelagic and demersal fish predators on gelatinous zooplankton in the Northeast Pacific Ocean - <strong>Brodeur</strong></td>
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<td>Cnidibase Acraspeda: a database on meduzoan cnidome - <strong>Morandini</strong></td>
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<td>Cnidome throughout the life cycle of scyphozoan species (Cnidaria, Scyphozoa) - <strong>R. Tiseo</strong></td>
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<td>Metalloproteinases in nematocyst venom from jellyfish <em>Nemopilema nomurai</em> are responsible for inflammation - <strong>Yu</strong></td>
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<td>Venom proteome of three blooming jellyfishes <em>Chrysaora caliparea</em>, <em>Cyanea nozakii</em> and <em>Lychnorhiza malayensis</em> (Cnidaria: Scyphozoa) from the coastal waters of India - <strong>Abdul</strong></td>
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**Poster speed presentation #2**

**MONDAY 4 NOVEMBER 2019: 14:55 - 15:40**

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| Studies on abundance of jellyfish along the coast of Greater Accra Region of Ghana - <strong>Adongo</strong> |
| Modelling of the effect of breakwaters on jellyfish distribution: the <em>Carybdea marsupialis</em> example - <strong>Bordehore</strong> |
| Ocean current modelling: the importance of ocean currents for range expansion of invasive jellyfish and comb jelly species - <strong>Jasper</strong> |
| Mapping the global distribution of floating hydrozoans <em>Velella</em> and <em>Porpita</em> - <strong>Helm</strong> |
| How to better calculate physiological respiration in jellyfish from enzymatic assays and enzyme kinetics - <strong>Packard</strong> |
| Potential of MALDI−TOF MS-based proteomic fingerprinting for species identification of gelatinous zoo plankton - <strong>Holst</strong> |
| Predation or photosynthesis? Nutritional variability of <em>Mastigias papua</em> using stable isotopes and fatty acids - <strong>Djeghri</strong> |</p>
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<td>Hydro-acoustic discrimination, and biomass estimation, of jellyfish along the Namibian coast</td>
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<td>Using unmanned aerial vehicles to measure jellyfish aggregations</td>
<td>Schaub</td>
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<td>The Arctic Jellies (ARJEL) project: investigating the impact of gelatinous zooplankton communities on changing Arctic ecosystems</td>
<td>Verhaegen</td>
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<td>Patterns of morphological development in Scyphozoa ephyrae (Cnidaria, Medusozoa)</td>
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<td>The reliability of morphological features to distinguish species within the upside-down jellyfish cryptic complex (Rhizostomeae: Cassiopeidae: Cassiopea)</td>
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<td>Histology of female gonads and oogenesis in Chiropsalmus quadrumanus (Cubozoa, Cnidaria)</td>
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<td>What makes blue jellyfish, blue? Searching for homologs of the new class of animal pigments from Rhizostoma pulmo</td>
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<td>Barcoding West African jellyfish – preliminary insights into species diversity off the west coast of Africa</td>
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<td>The symbiotic case study of zooxanthaeae living inside the jellyfish Cotylorhiza tuberculata</td>
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<td>The fatty acid profile of <em>Aurelia aurita</em>: significant differences between the bell and gonad tissues - <strong>McGuinness</strong></td>
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<td>The relative importance of gelatinous to crustacean zooplankton determined using six abundance and biomass methodologies - <strong>Brownlow</strong></td>
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<td>An unusual new jellyfish from estuaries along the south and east coasts of South Africa - <strong>Moodaley</strong></td>
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<td>World Atlas of Jellyfish: a new source of taxonomic data about cubomedusae and scyphomedusae - <strong>Morandini</strong></td>
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<td>First record of <em>Phyllorhiza punctata</em> (Cnidaria: Rhizostomae: Mastigiidae) in the Northeast Atlantic Ocean - <strong>Prieto</strong></td>
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<td>Legacy of Max Egon Thiel: an unpublished manuscript and a review about four decades of Rhizostomeae research since 1979 - <strong>Reinicke</strong></td>
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<td>Impact of microplastics in jellyfish</td>
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<td>Current trends in jellyfish blooms: investigating the impact of climate change through population modeling</td>
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<td>Effects of climate change on the distribution and diversity of gelatinous zooplankton in the Fram Strait (Arctic Ocean)</td>
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<td>A Preview of jellyfish diversity and ecology at the Kribi coastal zone of Cameroon, South-East Atlantic</td>
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Oral presentations
Jellyfish blooms along the southwest coast of India: current status and trends

Riyas Abdul, Biju Kumar Appukuttannair
Department of Aquatic Biology and Fisheries, University of Kerala, India

Jellyfish blooms are burgeoning global issues in many parts of the oceans world and the implications include socioeconomic losses, imbalances in biodiversity, productivity and oceanic health. Such blooms are frequent in Indian coastal waters and scyphozoans are the most predominant members involved. Jellyfish blooms along the southwest coast of India were recorded during 2016—2019 period and its abundance were measured through visual counts (3 x 3 meter area transects), trawling and shore seine operations. The major blooming species recorded were Crambionella orsini, Acromitus flagellatus, Netrostoma coerulescens, Chrysaora caliparea, Cyanea nozakii and Lychnorhiza malayensis. In the west coast of India majority of blooms occur towards the end of the southwest monsoon (June to September), while blooms of Crambionella orsini starts towards the end of monsoon last till post-monsoon (October January). Acromitus flagellatus blooms occurred in backwaters during November to May every year, which coincides with the summer season. The issues created by jellyfish blooms include hindrance to the fishing and aquaculture operations and impacts on tourism by way of stinging swimmers and loss of aesthetics of beaches. The seasonal abundance of major blooming species, ecological changes followed by bloom and the socioeconomic impacts of blooms on the fishery are discussed.
Phylogenetic relationships within the order Coronatae (Coronatae; Scyphozoa), with emphasis on genus *Nausithoe Kölliker*, 1853

Clarissa G. Molinari¹, Maximiliano M. Maronna¹, Botond Polgari², Allen G. Collins², Edgar Gamero-Mora¹, André C. Morandini¹,³
¹Departamento de Zoologia, Instituto Biociências, Universidade de São Paulo, Brazil
²National Systematics Laboratory, National Museum of Natural History, USA
³Centro de Biologia Marinha, Universidade de São Paulo, Brazil

The systematics of Coronatae (Scyphozoa, Cnidaria) has historically been based on morphological features of few specimens, and the majority of taxa were described more than 100 years ago. The difficulty of studying the external morphology of gelatinous animals can also cause incorrect assumptions about species relationships. In such case, the use of molecular data could be an important source to propose phylogenetic relationships. At the same time, however, the lack of specialized taxonomists for the group makes the genetic identity of the presumed coronate species questionable. This might be one of the reasons for the absence of a solid and robust phylogenetic proposal for the order until the present day. In this study we combine sequences from coronate species cultivated in our laboratory and those sequences available on GenBank to propose a basic phylogenetic framework for the group.
Hydrozoan pelagic diversity in Norway (Hypno) – project summary and selected results

Aino Hosia, Luis Martell
Department of Natural History, University of Bergen, Norway

Pelagic hydrozoans and other jellies are often excluded from zooplankton surveys, resulting in limited information on their diversity and distributions. From April 2015 to September 2018, the Norwegian Taxonomy Initiative project HYPNO studied the diversity of pelagic hydrozoans in Norwegian waters using integrative morphological and molecular methods. About 110 species of pelagic hydrozoans were confirmed as observed in Norwegian waters, including ten new species records for Norway and a few species probably new to science. DNA was collected from 99 species of Hydrozoans, covering ~80% of the pelagic fauna. So far, 85% (84/99 spp.) of the sampled species have been successfully sequenced for barcode compliant COI and 95% (94/99 spp.) for 16S, with generally good separation at species level. Combining morphology and DNA has resulted in novel insights in Hydrozoan taxonomy through linking life stages and identifying cryptic species. The project has also resulted in new observations on geographic distributions of several pelagic hydrozoans. In addition to further work on taxonomy and systematics, potential future applications of the accumulated data and tissue samples include monitoring gelatinous zooplankton distributions and trophic interactions through metabarcoding applications. A follow-up project focusing on the benthic stages of Hydrozoa (NorHydro, PI Luis Martell) is ongoing.
Mega-swarm of northern sea nettles (*Chrysaora melanaster*) in the Gulf of Alaska in the winter of 2019

**Brian P.V. Hunt**\(^1,2,3\), Alexei Somov\(^4\), Albina Kanzeparova\(^4\), Evgeny A. Pakhomov\(^1,2,3\), Vladimir Radchenko\(^5\)

\(^1\)Institute for Oceans and Fisheries, University of British Columbia, Canada  
\(^2\)Department of Earth, Ocean, and Atmospheric Sciences, University of British Columbia, Canada  
\(^3\)Hakai Institute, Canada  
\(^4\)TINRO, Russia  
\(^5\)North Pacific Anadromous Fish Commission, Canada

Between February 16 and March 18, 2019, the inaugural voyage of the International Year of the Salmon undertook a mesoscale survey of the Gulf of Alaska to research the winter ecology of the North Pacific salmon ecosystem. A total of 60 stations were sampled across an \(\sim 1 \times 1\) degree survey grid, covering an area of approximately 700,000 km\(^2\). An integrated fisheries oceanography approach was used to sample all components of the pelagic food web, from the bottom up drivers of physics and chemistry, to biota spanning microbes to salmon. Nekton sampling was completed using a midwater trawl towed for one hour at \(\sim 4.5\) knots. Here we report on the occurrence of an unprecedented bloom of the northern sea nettle *Chrysaora melanaster*. This species occupied the northern part of the survey area (\(\sim 300,000\) km\(^2\)) with abundance averaging 1,800 individuals.km\(^{-2}\) and a standing stock biomass of 1.23 million tons wet weight. Here we report on the population structure of *C. melanaster* as a means to infer the origin of this typically shelf associated species. Furthermore, we estimate the potential predation impact of *C. melanaster* on zooplankton in the Gulf of Alaska ecosystem.
Long-term changes in gelatinous zooplankton diversity and distribution in the Atlantic Gateway to the Arctic

Maciej K. Mańko¹, Sławomir Kwaśniewski², Waldemar Walczowski², Agata Weydmann-Zwolicka¹
¹Department of Marine Plankton Research, Institute of Oceanography, University of Gdańsk, Poland
²Institute of Oceanology, Polish Academy of Sciences, Poland

Pelagic ecosystems of the Arctic Ocean undergo rapid remodeling as a result of the climate change, accelerated by the increasing inflow of the Atlantic waters, called atlantification. Climate change already takes a toll on the zooplankton community of the European Arctic, affecting species phenology, food-web structure and prompting northward expansion of boreal taxa distribution ranges. However, lack of long-term observation data on jellyfish hampers any reasoning on their susceptibility to the ongoing changes. Here we analyze a unique dataset on jellyfish distribution and diversity spanning nearly 15 years (2001-2014), based on a continuous, yearly zooplankton sampling in the Atlantic Gateway to the Arctic, undertaken by the Institute of Oceanology of the Polish Academy of Sciences (IO PAN, Sopot, Poland). Combined with scrutinize oceanographic measurements these data allowed us to detect shifts in elusive pattern of jellyfish diversity and abundance distribution, identify changes in their phenology and demography and highlight the role of borealization in the gelatinous community structure in the Atlantic Gateway to the Arctic Ocean. These findings can be used for forecasting state of the pelagic realm in the warming Arctic and in constructing and tuning planktonic components of the ecosystem models.
Sexual reproduction in Acraspeda (Medusozoa, Cnidaria): a morpho-evolutionary approach

Gisele R Tiseo¹, André C Morandini¹,²

¹Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, Brazil
²Centro de Biologia Marinha, Universidade de São Paulo, Brazil

The resurrected clade Acraspeda – Staurozoa, Scyphozoa and Cubozoa – is compared based on the macroscopic and histological organization of gonad. The gonad of gastrodermal origin has the macroscopic morphology similar within the groups. In scyphozoans it presents variation in shape (oval, elongated, circular or “j” shape in Coronatae, semi-circle in Semaeostomeae and cross-shaped in Rhizostomeae). In staurozoans it extends from the base of the calyx to the apical region of arms. In cubozoans, it extends along the length of the septum (Carybdeida), while in Chirodropida they are more developed in the aboral portion. Histologically, the gonad in Staurozoa is organized into vesicles as evaginations of the gastrodermis with a gametoduct; in Cubozoa it is organized as a thin layer of tissue located between the mesoglea and gastrodermis; in Scyphozoa, it has three layers: an outer cylindrical-endodermal; an internal (genital epithelium); and the mesoglea with germ-cells. The oocytes of Semaeostomeae and Rhizostomeae present endogenous and exogenous yolk production. In exogenous route the yolk is transported through the trophocytes. The histological organization differs within Cubozoa and remains similar among Scyphozoa. The gametoduct appears to be the unique feature separating Staurozoa from the other Acraspeda like that the presence of trophocytes unites the Discomedusae.
**Chrysaora fulgida** adaptations to life in an upwelling system

Heidi Skrypzeck¹, Mark J Gibbons²  
¹Ministry of Fisheries & Marine Resources, Namibia  
²University of the Western Cape, South Africa

The west coast of southern Africa is swept by an eastern boundary current: the Benguela Current. It is a productive ecosystem, divided latitudinally into two by the world’s strongest upwelling centre at Lüderitz. Historically, the entire Benguela ecosystem has supported industrial fisheries dominated by small pelagic fishes, though following over exploitation only that in the south continues to do so. The northern Benguela ecosystem off Namibia is now characterized by jellyfish (*Aequorea forskalea* and *Chrysaora fulgida*), bearded gobies (*Sufflogobius bibarbatus*) and horse mackerel (*Trachurus trachurus capensis*). Here, we review what we understand about the ecology of *C. fulgida*, from which it is clear that this scyphozoan is supremely adapted to life in the upwelling ecosystem off Namibia.
Three-dimensional ecological niche modelling of midwater jellyfish: project outlook

Gerlien Verhaegen\textsuperscript{1}, Bastian Bentlage\textsuperscript{2}, Dhugal Lindsay\textsuperscript{3}

\textsuperscript{1}Japan Agency for Marine-Earth Science and Technology, Japan
\textsuperscript{2}University of Guam, USA
\textsuperscript{3}Japan Agency for Marine-Earth Science and Technology, Japan

The midwater, the oceans’ pelagic zone between 200 meters depth and the seafloor, is the largest continuous biome for multicellular organisms on our planet. Despite the technological advances in survey techniques over the last 30 years, less than 1\% of this vast and hard to reach habitat has been sampled. As pelagic ecosystems are being widely acknowledged for their relevance in ecosystem services, our knowledge gap concerning the midwater is becoming an increasing problem as it hampers our ability to predict how it will be affected by global change and anthropogenic pressures. Based on underwater video footage collected worldwide, we will study some of the most abundant and relevant midwater organisms: the hydromedusae (Cnidaria: Hydrozoa). Using ecological niche modelling in three dimensions (3D), we will answer fundamental questions regarding their ecology, distribution, diversity, and speciation mechanisms. The final output of our project will be a 3D interactive map projecting the realised niches of different midwater jellyfish species on a globe under present and future climatic scenarios. Our crucial findings regarding midwater ecology will allow us to predict how climate change will impact the midwater, and therefore give us a glimpse on what our oceans will look like in the future.
The effect of temperature and food availability on the asexual reproduction of *Aurelia aurita* and *Cyanea capillata*

**Amanda A. Wiesenthal**\(^1\), Chad Widmer\(^2\), Andrew S. Brierley\(^3\)

\(^1\)Pharmaceutical Biology, Saarland University, Germany  
\(^2\)Point Defiance Zoo and Aquarium, Tacoma, USA  
\(^3\)Scottish Oceans Institute, University of St Andrews, UK

Jellyfish species of the class Scyphozoa are known to undergo a complex multistage life cycle with free-swimming medusae that are the result of asexual reproduction (release of ephyrae) and can show large aggregations. Climate change along with anthropogenic influences on the oceans have led to environmental conditions that may favour jellyfish and enhance the forming of these blooms. The key to understanding blooming events and their development, however, lies within understanding the life cycle and especially the benthic stage of Scyphozoans and their response to environmental changes. Therefore, the effect of temperature and food availability on the asexual reproduction of *Aurelia aurita* and *Cyanea capillata* was explored over a 6-week period under different temperature and feeding conditions. Individuals of each species were held at one of 4 temperatures (4°C, 10°C, 16°C or 23°C) and were either fed to saturation with artemia nauplii every third day or starved completely. We found that both temperature and sufficient food supply increased the number of new scyphistomae produced by *Aurelia aurita*, yet did not have a clear effect on the production of podocysts. In *Cyanea capillata*, the number of released ephyrae decreased with increasing temperature and under food deprivation.
Coastal acidification does not exacerbate effects of hypoxia on the settlement and swimming behaviour of creeping polyps of the Irukandji jellyfish, \textit{Alatina alata}

\textbf{Sheldon Rey Boco, Kylie Pitt, Steven Melvin}  
\textit{Griffith University, Australia}

Low dissolved O$_2$ (hypoxia) and low pH (acidification) co-occur in many coastal marine ecosystems and can threaten marine life but the combined effects of these stressors on the asexual buds of jellyfish polyps have not been studied. We examined the interactive effects of hypoxia and acidification on the survival, number of tentacles, settlement rate and swimming behaviour of creeping polyps of the Irukandji jellyfish, \textit{Alatina alata}. The experiment consisted of two orthogonal factors: dissolved O$_2$ (ambient 6 mg/L and hypoxic 1.5 mg/L) and pH (ambient (8.0) and low (7.7)). Creeping polyps were exposed to experimental treatments for 42 hours. Rates of survival were higher in hypoxic conditions, regardless of pH and more polyps settled in the individual hypoxia and low pH treatments compared to ambient treatments. The experimental treatments did not affect the number of tentacles produced but creeping polyps were less mobile and had reduced velocity after 4-hr exposure regardless of treatment. The results suggest that hypoxia and low pH individually enhance the settlement rates of creeping polyps and that \textit{A. alata} creeping polyps may be robust to predict changes in tropical coastal waters.
Transparent world: Siphonophores made of glass

Götz-Bodo Reinicke¹, Susan Liebold², Cornelius Réer², Uwe Beese¹

¹Deutsches Meeresmuseum, Germany
²Glaswerk-atelier, Germany

For the production of attractive exhibition models of translucent, fine-skinned, planktonic marine animals such as siphonophores (Siphonophorae), the use of glass offers an obvious solution. However, this material implies demands on design and craftsmanship, which go far beyond those for commercial glass-based products. Inspired by the 19th century Bohemian scientific glass artists L. and R. Blaschka in Dresden, in 2010 the authors attempted to build on the use of glass for the creation of museum models. The Thuringian artist Susan Liebold developed working techniques for the production of models after natural organisms, based on her freely designed fluorescent objects made of clear, chemically enriched Schott-glass. Using the (original) descriptions, live video footage and preserved animal material, the individual "components" of the hydrozoans Nanomia cara (Agalmatidae) and "Portuguese-man o’ War" Physalia physalis (Physaliidae) were crafted and assembled for model presentation. The fascination of the unique exhibits lies in the interaction between the intended fidelity to the living organisms and the mysterious, delicate appearance of artistically designed glass displays. The charisma of large glass models lives from the surprising vividness of objects that often elude easy, everyday understanding. The mostly unexpected information that it is about glass models generates unbelieving, often enthusiastic, amazement.
Ernst Haeckel’s mysterious cubomedusan species

Ilka Straehler-Pohl
Medusa’s Nursery Private Laboratory for Life cycle, Development and Evolutionary Research, Germany

Haeckel was one of the most disputed scientists of the 19th century due to his partial support of Darwin’s theory and their friendship, of further developing his own recapitulation theory ("ontogeny recapitulates phylogeny") of evolution and establishing the disputed and nowadays disproved biogenetic law or embryological parallelism. Haeckel’s ideas were often speculative and lacked mostly of empirical support which tarnished his scientific credentials. Additionally, he was accused of falsification concerning drawings, commented and denied several times by Haeckel himself which might have led also to general doubt concerning his description of new species. Haeckel described about 18 new Cubozoa species in his “System der Acraspeden, 2. Hälfte des Systems der Medusen” at the end of the 19th century. Fourteen (14) of 18 of Haeckel’s new cubozoan species were doubted or declared invalid by many authors in the past and present due to doubtful material, lost type material, his species never turned up again or his species were declared as synonyms of already described species.

New research results will shed new light on Haeckel’s doubtful species, showing where the doubt was right and where it was wrong.
Jellyfish mucus as a means to combat plastic pollution?

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Recent research has shown that gold nanoparticles may be captured by mucus released from jellyfish. This finding has served as one of the bases for the Horizon 2020 GoJelly project which endeavors to harvest jellyfish and use them as a resource for a variety of practical purposes, including the capture of micro- and nano-plastics (MP). Plastic debris has become a severe and growing environmental problem, as a consequence of increasing global production, the disposable use of plastics, and the materials’ longevity. One of the heretofore unaddressed sources of MPs released into the environment is urban wastewater treatment plants, and GoJelly plans to explore the feasibility of capture and removal of MPs from WWTP effluents.

We examined MP capture by mucus extracted from three different species of jellyfish, *Rhopilema nomadica*, *Aurelia* sp. and *Phyllorhiza punctata* using different mucus extraction methods and types of MPs. Thus far, the mucus of *Aurelia* sp. demonstrated the best capture properties, with respect to MPs tested. We have tested fresh, frozen and lyophilized mucus and these yield different MP capture outcomes. Ongoing and future work will test the dose response of *Aurelia* sp. mucus, MP capture efficiency, and additional types of MPs.
Limited impacts of microbeads to *Aurelia aurita* medusae

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Microplastics are ubiquitous in marine environments and are readily ingested by many species. Jellyfish have the potential to ingest large quantities of microplastics, as they are filter feeders that have high clearance rates. Ingestion rates and potential impacts of microplastics on the physiological and physical functioning of jellyfish, however, have not been assessed. We quantified rates at which microbeads were ingested by medusae of *Aurelia aurita*, and used histopathology to determine if microbeads damaged tissues in the gastrovascular cavity. Medusae of *A. aurita* were exposed microbeads at a concentration of 2 particles mL⁻¹ and numbers of microbeads on the ex-umbrella, sub-umbrella, tentacles, oral arms, manubrium, and within gastric pouches were counted in six replicate medusae that were randomly sampled after 1, 2, 4, 8, 16 and 32 hours exposure. Microbeads were observed in all structures but were completely evacuated from the gut within 32 hours of exposure. No abrasion or damage was observed in gut tissues. Our results indicate that *A. aurita* efficiently egest microbeads and are unaffected by their ingestion.
A project of jellyfish disaster prevention for the nuclear power plant in China

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The jellyfish blooms, occurred frequently since the end of the 20th century in China coastal sea, not only do affect marine ecosystems, but also threaten the operation of major facilities along the coast. Here we introduce a China jellyfish project which aims to develop prevention and control system for jellyfish disaster in the water intake area of the Hongyan River Nuclear Power Plant (HoRNPP) in the North of China. Through field investigation, indoor experiment, and historical data analysis, we clarify the main disaster-causing species, their occurrence time and relationship with the physical environmental factors. Three different models were built to predict jellyfish outbreak in the short term, their drifting path, and population fluctuation. The jellyfish monitoring and warning network were established in the waters around the plant. We also proposed the scheme of how-to layout anti-jellyfish nets and a plan of physical guidance mitigation. We develop the draft of a technical guideline to clarify the main working procedures and technical requirements for prevent the jellyfish disaster to the HoRNPP.
Comparative transcriptomic identification of venom proteins in the clinging jellyfish 

*Gonionemus vertens*

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Although native to the Pacific Ocean, the clinging jellyfish, *Gonionemus vertens*, has invaded numerous locations globally. The medusae are small (25-mm bell dia.) but can possess potent stings that can lead to systemic pain and disrupted neurocognitive function. They are typically found in eelgrass beds during the summer months when the population peaks, thus they pose a substantial seasonal public health concern. To explore the nature of this species' toxic sting, transcriptome libraries were constructed from poly A+ mRNA isolated from five individuals and sequenced on an Illumina Mi-Seq platform. Raw RNA-seq data were assembled *de novo* using Trinity and assembly quality was verified via BUSCO analysis. The resulting transcriptome was annotated with DIAMOND and contigs were aligned against existing databases using BLASTx. Comparative bioinformatic strategies were employed to identify putative venom proteins falling into broad categories such as phospholipases, metalloproteases, C-type lectins, disintegrins, and kunitz-type protease inhibitors—a cocktail of proteins connected to the observed physiological symptoms of envenomation. Continued analysis of venom may clarify the potential human health threat these invaders pose, lead to improved treatment options for sting victims, and provide inspiration for the design and development of novel pharmaceuticals targeting pain and neurological disorders.
Spatiotemporal distributional pattern of *Nemopilema nomurai* monitored using sighting, trawl net and plankton net in Yellow Sea and Liaodong Bay of Bohai Sea during 2017-2019

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*Liaoning Ocean and Fisheries Science Research Institute, Key Laboratory of Marine Biological Resources and Ecology, China*

From 2017 to 2019 *Nemopilema nomurai* were monitored in the Liaodong Bay of Bohai Sea and the northern part of YS at the same time from May to September, using sighting, trawl net and plankton net with different diameter. The results showed: i) The strobilation beginning time was ca 11-13 °C from late April to early May, and temperature ca. 14 °C or less, ephyrae liberation occurs in the northern LDB. ii) The first appearance of *N. nomurai* metaephyrae or juveniles was in the northern inner coastal areas as every year (May-June), larger juveniles and young medusa of *N. nomurai* were located in more southern and deeper sea areas of the tip of Liaodong Peninsula. This was interpreted as a horizontal advection of the *N. nomurai*’s population that accomplishes their whole life cycle in LDB and the southern waters of Liaodong peninsula. It is possible that a small number of *N. nomurai* initially appeared in the northern part of LDB passed through the Bohai Strait, reached southeast Liaodong Peninsula, YS. iii) *N. nomurai*’s population was observed in August, centrally distributed in the two parts of the East and West of northern part of YS. The number of Yellow Sea exceeds Bohai in September. Afterward, population size decreased, umbrella size continuously and gradually diminished, and medusae died probably.
Recent changes in the phenology of scyphozoans in the southwestern Mediterranean Sea

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The Mediterranean Sea is one of the most impacted seas in the world due to the synergistic interactions of climate and unprecedented anthropogenic pressure linked with pollution, eutrophication, overfishing, habitat destruction and species introductions. Among the current threats is the proliferation of potentially harmful jellyfish populations and specifically scyphozoans, which are ubiquitous components of the dynamics of pelagic ecosystems and have been recorded on a long time in the Mediterranean Sea. We here assess the response of the dominant scyphozoans in the southwestern Mediterranean Sea to climate changes during the last 25 years. The growing recurrence of large, long lasting proliferations and changes in the phenology of holoplanktonic (*Pelagia noctiluca*) and meroplanktonic species (*Rhizostoma pulmo*) provide evidence of direct impacts of regional climate change (sea surface temperature and meridional winds) on decadal abundance trends of these jellyfish. In addition, changes in the plankton food web configuration promoted by coastal eutrophication appear associated with the increase of *R. pulmo*. Our results provide compiling evidence of the additive effects of climate and anthropogenic pressure on coastal ecosystems, where the jellyfish increase emerge as genuine indicators of the Mediterranean ecosystem health.
THE CRYPTIC AND INTEGRATIVE ECOLOGY OF MEDUSAE AND POLYPS

The past two decades have seen dramatic advances in the technologies available for measuring and understanding all aspects of jellyfish ecology in the lab and in the field. However, information generated often remains largely within disciplinary boundaries and focused on subsets of life-history stages or geographic regions. The goal of this session is to highlight research that brings together multiple lines of evidence to provide a more integrative understanding of what we know, and to better reveal what we don’t know, about the diversity and biogeography of jellyfishes, their functional biology, and ecological roles.

Conveners:

Michael N Dawson, Cheryl Ames, Bastian Bentlage, Agustín Schiariti, André Morandini
Distribution of polyps of *Aurelia coerulea*: strong evidence of anthropogenic causation of the jellyfish blooms

Jinho Chae1,2, Wonduk Yoon2, ByeongHo Kim1, Gunhee Sung1, Changgyun Yu1, Kiyeon Hahn1, Inseo Hwang1, Gusung Lee3, Sunwoo Kim3, Hojung Song3

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We located polyp populations of *Aurelia coerulea* and determined their total amount around the Korean coast using underwater photographs collected by SCUBA diving. We have made diving observation approximately in 1,500 sites, finding important (significantly large) polyp populations from more than 500 sites. The downward-facing surface of floating piers, barges in aqua-farm and marina were the most frequently observed habitats of the jellyfish polyps among a variety of artificial structure providing polyps’ habitat such as concrete dock walls, dike ripraps, submersing pillars of industrial facilities, abandoned fishnet and artificial reefs. The highest occurrence of polyps was observed on floating structures made of steel or concrete, and dike ripraps, while the density was not significantly different between qualities of materials. Direct attachment on bare substrates was the most frequently observed in floating structures, followed by shell surface of oysters. On the other non-floating structures, there is little difference in polyp occurrence between the surfaces of the bare substrate, shells of mussels, oysters and tube-making polychaetes. Only a polyp population was found in natural habitat, the bedrock of Manjaseo. These results provide strong evidence that increase of coastal development and construction is the major causation of the jellyfish blooms.
Aurelia aurita polyp response to simulated Marine Heatwaves

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The increase of jellyfish blooms has been associated, among other factors, with anthropogenic climate change. Alongside global warming, Marine Heatwaves (MHWs) have been observed in recent decades in the ocean. MHWs are periods of anomalous warm sea surface temperature which can last multiple days or even months. Marine ecosystems and fisheries have been shown to be highly vulnerable to MHWs. Mortality, local extinctions, shifts in community structure and depleted biodiversity are some major consequences for marine biota. Furthermore, MHWs are expected to become more frequent, longer and extreme. Here we present the response of Aurelia aurita polyps to simulated MHWs. We measured metabolic rates, growth, reproduction and survival. The metabolic rates were determined by measuring respiration with optodes and the enzymatic activity was linked to mitochondrial metabolic pathways (Respiratory Electron Transport System and Krebs Cycle). Our results reveal that A. aurita polyps can resist MHWs from 6 up to 20 days. Therefore, in a future where MHWs affect the global biodiversity, a loss in A. aurita polyp populations is unlikely.
Will *Cotylorhiza tuberculata* population increase under future Mediterranean acidification and temperature conditions?

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The world’s oceans are becoming warmer and more acidic as a consequence of climate change and the increasing uptake of atmospheric CO\(_2\). However, little is known about the impact of predicted future conditions on jellyfish, particularly on their early developmental stages. In this work, the interactive effect of rising temperature and ocean acidification on the physiology of the scyphozoan *Cotylorhiza tuberculata* polyps was examined to determine future responses of population dynamics in the Mediterranean Sea. Organisms were then exposed to different temperature and pH conditions predicted by IPCC for RCP8.5 scenario. Experiment 1 combined current winter conditions (18°C) and both pCO\(_2\) (400ppm and 935ppm) levels to detect effects on survival and asexual reproduction. Experiment 2 mimicked the current and future summer temperatures (24°C and 30°C) and pCO\(_2\) levels and was focused on assessing the response of the strobilation phase, essential for the adult phase to occur. Our results show that *C. tuberculata* polyps are quite tolerant to future Mediterranean conditions in the short term, surviving and reproducing asexually. However, these organisms are unlikely to thrive in the long term because acidification and temperature may affect statoliths formation and hence, the development and fitness of the ephyrae.
Hyposalinity and incremental micro-zooplankton supply in early-developed *Nemopilema nomurai* polyp survival, growth, and podocyst reproduction

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Early-developed polyps of the giant jellyfish *Nemopilema nomurai* that are sexually produced during the rainy season form the principal recruitment for benthic population stages, regulating the mass outbreaks of medusae that occur in east Asian marginal seas. Their survival, development and subsequent asexual reproduction are likely facilitated by hyposaline seawater and potentially enhanced micro-zooplankton around the estuaries that comprise the major nurseries of medusae. In this study, 8-tentacled polyps that developed from planulae were incubated at 11 salinities from low to high (8, 11, 13, 15, 18, 20, 23, 25, 28, 31, 33) with 3 feeding frequencies (once every 3 d, once every 9 d, unfed; *Brachionus plicatilis* concentration: 0.16 mg C L$^{-1}$) at a constant temperature (19°C). Survival rate of early-developed polyps increased 3-fold at salinities 11 to 20, >80% greater than at salinities 25 to 33. The composition of fully developed polyps, somatic growth, and podocyst diameter positively depended on food supply, except at salinity 8. The potential podocyst production of polyp colonization reached normal peak at salinity 20 in the group that was fed once every 3 d. Excystments were significantly restricted at salinity <20. These findings confirm that estuarine areas with salinities from 11 to 20 are appropriate for *N. nomurai* polyp colonization, where prospectively increasing micro-zooplankton supply rooted in frequent eutrophication may benefit polyps. An asexual reproduction strategy also corresponded with autumn salinity fluctuations. The intensity of diluted water and monsoonal rainfall, as well as plankton supply around the estuaries in autumn may fundamentally affect polyp abundance and size, determining the population size of medusae in the following spring.
Seasonal dimorphism in the ontogenetic development of moon jellyfish *Aurelia coerulea* and the contribution of the direct-development life cycle type to the population dynamics in Maizuru Bay, Japan

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Outbreaks of moon jellyfish *Aurelia* are frequently reported from many parts of the world’s coastal areas. Planulae of *Aurelia* canonically transform into sessile polyps, which can drastically increase in number through budding and strobilation; such asexual reproduction has been recognized as one of the major causes of the outbreaks. *Aurelia* also shows direct development that lacks asexual reproduction, which complicates the mechanisms of its outbreaks. To clarify the seasonality of the polyp-forming and direct-development life cycles of *Aurelia* and the contribution of the direct-development life cycle to the population dynamics, we conducted field observations in Maizuru Bay, Japan. If available, planulae were sampled and incubated. From July until October (> 20°C), *Aurelia coerulea* produced smaller eggs (diameter: approximately 200 \(\mu\)m) and planulae (length: approximately 300 \(\mu\)m), all of which developed into polyps. However, from December until May (< 20°C), overwintering medusae produced larger eggs (diameter: approximately 400 \(\mu\)m) and planulae (length: approximately 700 \(\mu\)m) and 90% of the planulae developed into ephyrae, bypassing the sessile polyp and strobila stages. Moreover, ephyrae and young medusae occurred more abundantly, if medusae were abundant in the preceding winter. This finding suggests that overwintering medusae influence the population size through the direct-development type reproduction.
Backtracking a bloom: Where to find the scyphopolyps?

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Causes and consequences of jellyfish bloom formation are subject to controversial discussions worldwide. While medusae are studied to a broader extent, polyp stages of scyphozoans are under investigated thus limiting reliable prediction of jellyfish bloom formation. One of the aims of the EU-project GoJelly, is to increase our knowledge on jellyfish population dynamics with a strong focus on bloom predictions by taking the phenology of scyphopolyps in several European case areas into account. This study aimed to investigate scyphopolyp colonies in the Trondheimsfjord (Norway) during a field survey in 2018 by analysing distribution patterns, habitats and interactions between scyphopolyps and other settling epibionts. Polyp colonization patterns on natural substrates and settling plates were analysed along the Trondheimsfjord coastline. By applying molecular tools, the occurrence of *Aurelia aurita* polyps was confirmed while polyps of the genus *Cyanea* were not observed. Shallow and sheltered littoral zones were proven to be viable polyp habitats. The surface of *Ascidia mentula* (solitary ascidian), *Pomatoceros triqueter* (polychaete) tubes and dead *Balanus balanoides* (barnacle) shells promoted viable polyp microhabitats while *Mytilus edulis* (blue mussels) functioned as a potential competitor for space and food towards other settling epibionts, including *A. aurita* polyps.
Transgenerational effects facilitate acclimation to a varying climate in *Aurelia aurita* polyps

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Uncertainty surrounding the sporadic appearance of scyphozoan medusae stems partly from their metagenic life cycle and partly from population specific responses to environmental cues. Polyps are key to the formation of seasonal scyphozoan blooms and drive the appearance of medusae in coastal environments. In recent years, much research has focused on understanding polyps’ responses to a changing environment. However, most studies do not distinguish between different generations within the asexual polyp phase. It is unclear how much of polyp response to forcing variables can be attributed to *in situ* environmental conditions such as temperature, or offspring phenotype driven by the parental environment. We hypothesised that different maternal temperatures would modify offspring polyps’ reproductive output and initiation of bud production. We monitored polyps’ reproduction in response to summer temperatures (15, 17, 19°C) over three successive asexual generations. Production of directly budded polyps dominated all groups. There was some evidence of transgenerational effects modifying reproductive output across multiple asexual generations which could allow successive generations of polyps to respond to environmental stressors as well as future climate change and global warming.
The Ellis Island effect: invasive hydrozoans in the mid-Atlantic

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For the last two centuries, human migration to the United States has opened potential pathways for invasive species. In particular, Ellis Island in New York Harbor was the dominant port of entry for over 12 million migrants. As such, this provides a proximal mechanism for the introduction of non-native species to the western mid-Atlantic coast. Hydrozoans' diminutive size and cryptic nature may make it difficult to identify active invasions, however molecular approaches have proven to be effective at identifying invaders. During the last 3 years, we have documented five non-native hydrozoans in New Jersey using molecular techniques. Gonionemus vertens, Gastroblastra raffaelei, Moerisia spp., and Bougainvillia spp. have origins hypothetically linked to the Mediterranean indicating a potential group invasion from that region. Aequorea australis is a Pacific hydrozoan whose origin pathway is yet unknown but has now become abundant in our region. As the benthic polyp stages of these species are diminutive (<2mm) and pulses of medusae are infrequent, identification of these species was most likely overlooked in species inventories. However, the use of molecular sequencing of COI and 16S have allowed us to identify these species for the first time in this region.
Molecular phylogeny of the upside-down jellyfishes (Rhizostomeae: Cassiopeidae: *Cassiopea*): implications on their origin and diversification

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*Cassiopea*, the upside-down jellyfish, is widely distributed throughout shallow tropical and subtropical marine and estuarine habitats, being the only genus within the suborder Kolpophorae with representatives both in the Western Atlantic and the Indo-Pacific region. Despite their early origin within Rhizostomeae and their large geographic distribution, the genus *Cassiopea* and the family Cassiopeidae have a modest taxa richness compared with other families of rhizostomes. However, the present status of Cassiopeidae diversity is uncertain and could be underestimated by cryptic forms and poor collecting efforts. Understanding the systematics of *Cassiopea* has become a priority because it is gaining ground as a model species; thus, in order to elucidate their origin, species richness and phylogenetic relationships, we analyzed DNA sequences (newly generated and from online repositories). We were able to recognize a division between Atlantic and Indo-Pacific lineages. Also, molecular evidence revealed hidden diversity in the Indo-Pacific clade, allowing us to recognize new species. Based on a molecular-clock analysis, the upside-down jellyfishes diverged from its sister group during the late Cretaceous, and our results support the hypothesis of an Indo-pacific origin and later colonization of the Atlantic basin. Finally, we discuss the events most likely related with their diversification.
Morphological overlap hinders diagnosability: recognizing cryptic diversity in *Aurelia* (Cnidaria, Scyphozoa)

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Integrating all useful evidence is paramount for the construction of species hypotheses, although a daunting task, particularly in groups that cryptic species occur. When morphology cannot be used reliably to distinguish species, taxonomists can produce formal descriptions using other evidence, including genetics. By combining morphological and molecular data, we embraced this challenge for the genus *Aurelia*, for which recent studies delimit at least an additional 16 species from those previously recognized. Our results show that morphological features of medusae from very distinct localities overlap. Even though some features seem responsible for most of the variation, there is not even a regional geographic structure on dissimilarities. This is emphasized by the morphological differences found in the comparison of lab-cultured *A. coerulea* medusae with the species' diagnosis. Previous studies have highlighted the difficulties in distinguishing polyps and ephyrae across *Aurelia* species, as well as the potential for plasticity. Based on molecular data, we recognize 28 species within *Aurelia*, of which seven were already described, six are new to science, four are resurrected and 11 are still under discussion. This does not mean morphology should be left aside, we are only beginning to understand the evolutionary processes involved in morphological change and speciation.
The effect of temperature on embryonic development and planulae settlement of *Nemopilema nomurai*

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In this study, laboratory experiments were conducted for 12d to determine how temperature (15, 18, 21 and 24°C) affects embryonic development, swimming speed, survivorship and settlement of planula, and subsequent development of metamorphosed polyps. Results showed that the rate of embryonic development significantly decreased with decreased temperature, whereas more fertilized eggs (96%) could develop to planula in 15°C, and only 50% in 24°C. The planula settlement was promoted by a decrease in temperature, however temperature of 15°C significantly increased planktonic larval duration and settled polyps had morphological deformities. The temperature also significantly affected the settlement behaviour and morphology of planula larvae. Time required to attain first settlement was 17h at 24°C, 28h at 21°C, 36h at 18°C, and 72h at 15°C. The settlement ratio was highest for 4d at 24°C, and for 12d the highest was at 15°C. Compared with the lower temperature the planula was tall and slender in higher temperature. Our results suggest that temperature changes would affect both the dispersion and distribution *N. nomurai* planula and the size of polyp population, and temperature adjusts the reproductive distribution between planula and polyp to regulate the medusa population.
Transgenerational effects of temperature influence asexual reproduction in scyphistomae of the bloom-forming and invasive jellyfish *Aurelia aurita*

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*University of Southampton, UK*

The common jellyfish, *Aurelia* spp., has successfully invaded non-native habitats around the world. To understand the underlying reasons behind the success of *Aurelia* spp., research has typically focused on the effects of changing environmental conditions on scyphistomae of single or unknown generations. It is unclear, however, how scyphistomae respond to changing conditions over longer time-scales and multiple asexual generations, and how those responses influence successful translocation of populations and the proliferation of blooms. Here, we examined the role of transgenerational effects in asexual reproduction of *Aurelia aurita* scyphistomae under different temperatures over 72 days. Newly-settled scyphistomae from three thermal origins were each exposed to three different temperatures (8°C, 12°C, 16°C) to test the null hypotheses that thermal history of the mother generation does not affect asexual reproduction in the offspring generation. A cross-generational increase in temperature triggered early initiation of asexual reproduction and yielded greater reproductive output in the offspring generation, with the opposite trend observed with cross-generational cooling. Transgenerational warming that occurred at the higher end of the thermal range was more advantageous in initiating budding. A low temperature of 8°C constituted a physiological limit for *A. aurita* scyphistomae in the offspring generation, causing considerable inhibition to asexual reproduction.
The recovery after the damage: chronic exposure of polyps to a cocktail of pesticides has no effect on ephyrae

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Scyphozoan jellyfish have complex life cycles, with most species including larval, polyp, ephyra and medusa stages. Stressors experienced during one life-history stage may influence subsequent stages (so called carry-over effects). Due to agricultural run-off, jellyfish in coastal waters are frequently exposed to ‘cocktails’ of pesticides that may act synergistically to impair their fitness. We hypothesized that ephyrae produced from polyps exposed to pesticides would be less fit than ephyrae produced from polyps not exposed to pesticides and that combined exposure to two pesticides would have worse effects than exposure to individual pesticides. Polyps of \textit{Aurelia aurita} were exposed for one month to two pesticides: atrazine (0 and 2.5µg/L) and chlorpyrifos (0 and 0.04µg/L) in a full factorial experiment. The resultant ephyrae were then re-exposed to the same conditions as their parent polyps or to filtered sea water (FSW) for another 21 days. Ephyrae that were re-exposed to the same conditions as their parent polyps had more deformities and faster growth rates than those transferred to FSW. Polyps exposed to individual pesticides produced ephyrae with higher respiration rates than polyps exposed to both pesticides. We conclude that detrimental effects of atrazine and chlorpyrifos on polyps do not carry-over to ephyrae of \textit{A. aurita}. 
Experimental evidence that statolith elemental chemistry can elucidate the movements of an elusive Hawaiian cubozoan

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Knowledge surrounding the movements of jellyfish is limited, but elemental chemistry has the potential to elucidate these movements. Correlative evidence has previously suggested that a relationship exists between the elemental chemistry of cubozoan statoliths and environmental variation. Here we present evidence through use of a manipulative experiment on the well-known cubozoan species, Chironex fleckeri, that a relationship exists between statolith elemental chemistry and temperature. Strong evidence was found that statolith Sr:Ca varied with temperature and that this was independent of salinity. As Sr:Ca ratios in saltwater varied little with variation in temperature or salinity a physiological mechanism within C. fleckeri must have affected statolith Sr:Ca, causing it to vary with temperature. Evidence is also provided that Sr:Ca varied with temperature in another cubozoan, Copula sivickisi. We applied Sr:Ca as a proxy for temperature for a cubozoan that is thought to make excursions to deep water in Hawaii. We ground truthed the technique for, Alatina moseri and concluded that this species makes regular excursions to depths of about 400m. Elemental chemistry, therefore, has the potential to reveal more about the horizontal and vertical movements of cubozoans.
An integrative approach for the assessment of diversity and distribution of polyps and their medusae in Norwegian waters

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The frequent separation of the study of polyp and medusa stages has led to incongruences in our knowledge of medusozoan diversity and distribution, even in relatively well-studied regions such as the Northeastern Atlantic. By using an integrative approach that combines DNA-barcoding (both mitochondrial 16S and COI), analysis of cnidome, and careful morphological examination of live and preserved specimens, we have identified several cases of cryptic taxa, as well as issues in species delimitation and incongruences in the identification of different stages in the life cycle of Norwegian hydroids and hydromedusae. The polyp stage of the medusa-based species Ptychogena lactea is described, polyps from the morphologically similar families Mitrocomidae, Lovenellidae, and Campanulinidae are for the first time unambiguously identified from material collected from the field, and cryptic diversity in the jellyfish Tiaropsis multicirrata is discovered. Set to produce an up-to-date list and a comprehensive library of DNA sequences for the species found in Norway, the results and experiences of our current (NorHydro) and previous (HYPNO) projects demonstrate that supraspecific and species level taxonomy in Norwegian medusozoans is still rewarding and that many interesting findings are to be expected in the near future.
Rhizostoma luteum; a large jellyfish to be rediscovered

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Until summer 2012 Rhizostoma luteum was a forgotten species, and even some scientist doubted its occurrence, believing it might be a young Rhizostoma pulmo or a local variation. The first mention of this large Scyphozoa was by Quoy and Gaimard in 1827 from the Strait of Gibraltar (southern Iberian Peninsula). We describe for the first time, the life cycle of this jellyfish and compare it with early life history stages of its sibling species Rhizostoma pulmo and Rhizostoma octopus. We observed only one asexual reproduction mode, which is employed for propagation, consisting of podocyst formation with excystment, subsequent development of scyphistoma, strobilation and liberation of viable ephyra. Furthermore, the development of ephyra to metaephyra was photodocumented, reaching the metaephyra stage in approximately 21-25 days. The life cycle of R. luteum resembles that of its congeners, with the distinction that it has the unique feature of being a brooding species (internal fertilisation with subsequent release of planulae) and under the conditions tested, the predominantly strobilation type observed was monodisc, and not polydisc as with the other two species in the genus Rhizostoma. Thus, to better understand its ecological roles, it is essential to study its life cycle.
Sunbathing jellies: What do we know of zooxanthellate jellyfishes?

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Some jellyfishes undergo a photosymbiotic relationship with dinoflagellates (zooxanthellae). Zooxanthellate jellyfishes, however, remain little studied relative to non-zooxanthellate jellyfishes and scleractinian corals, and the relevant literature is often scattered. To provide a more integrated and synthetic understanding of zooxanthellate jellyfishes, we reviewed the published literature on their diversity and ecology. Photosymbiosis with zooxanthellae originated at least seven times in Medusozoa. Of these, five involve taxa with a pelagic phase. Zooxanthellate jellyfishes bring together two complex traits: (1) the metagenetic life cycle of jellyfishes and (2) the photosymbiosis. By reviewing the impact of zooxanthellae on jellyfish’s life cycle and nutrition, we show that the interaction of these two complex traits became more than the sum of its parts. We emphasize three emergent characteristics and explore their potential impacts on zooxanthellate jellyfish ecology: (a) zooxanthellate medusae, as holobionts, are generally mixotrophic, deriving their nutrition from both predation and photosynthesis, (b) zooxanthellate polyps, although capable of hosting zooxanthellae rarely depend on them, and (c) zooxanthellae play a key role in the life-cycle of jellyfish by allowing or facilitating strobilation. Finally, we summarize the current gaps in our understanding of zooxanthellate jellyfishes’ biology and ecology, and propose some guidelines for future studies.
The macroecology of the megamedusae

Michael Dawson  
*University of California, Merced*

The past two decades have seen dramatic advances in the technologies available for measuring and understanding many aspects of jellyfish biology and ecology in the lab and in the field. A major goal should now be to enhance the integration of these datasets. Macroecology — the study of broad scale ecological patterns and processes, typically focusing on multiple communities and ecosystems, to infer principles that describe broad statistical patterns of abundance, distribution and diversity — is one of several possible frameworks. Here, we explore this approach, integrating recent molecular phylogenetic, genomic, phenotypic trait, and environmental data describing the largest of the medusae: the scyphomedusae. A goal is to bridge traditional boundaries, thereby increasing knowledge, information transfer, and encouraging a more synthetic understanding, and approach to future studies of jellyfishes. We also encourage approaches such as establishing more wide-reaching long-term integrative datasets, coordinated globally.
The evolutionarily conserved molecular dynamics of strobilation

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Scyphozoan polyps transform into medusae through a process termed strobilation, where the oral end of a polyp metamorphoses into one or many ephyrae. Both internal and external cues are important for initiating strobilation, however, the cellular and biochemical signals that integrate these cues and initiate strobilation are unknown. We discovered that a class of molecules termed “indoles” reliably trigger strobilation across a broad diversity of scyphozoan polyps. Because indoles induce strobilation in diverse scyphozoans, we hypothesize that indoles are acting on an evolutionarily conserved genetic pathway for strobilation induction. Using RNA-seq, we identified several promising gene candidates involved in strobilation initiation, which are also involved in the earliest steps of metamorphosis in other animals. We will discuss these findings in both evolutionary and ecological contexts, including the possible sources of naturally occurring indoles or other ligands, as well as potential indole pollutants and the impact these molecules may have on medusa production. Finally, we will suggest future steps to determining the role these molecules may play in the strobilation of wild polyps.
ROLE OF JELLYFISH IN ECOSYSTEM STRUCTURE AND FUNCTION: FROM PREDATOR-PREY INTERACTIONS TO BIOGEOCHEMICAL CYCLING

Jellyfish are now known to play a significant role in the structure and function of marine food webs. Through DNA analysis of faecal and gut samples of predators, stable isotope analysis and the deployment of animal-borne cameras, there is a growing awareness that jellyfish are routinely consumed by many taxa. Jellyfish are also hugely effective predators that convert large amounts of plankton carbon into gelatinous biomass, possibly limiting its transfer to higher trophic levels, although metabolic by-products and jelly falls may play a significant role in the biological carbon pump. This session invites abstracts that provide insights on the role of jellyfish in ecosystem structure and function from predator-prey interactions to biogeochemical cycling.

Conveners:
Cathy Lucas, Tom Doyle, Jonathan Houghton, Nathan Hubot
Resilience of *Aurelia aurita* to zooplankton regime shifts

Emily G. Mitchell\textsuperscript{1,2,3}, Margaret Wallace\textsuperscript{1}, V. Anne Smith\textsuperscript{2}, Amanda A. Wiesenthal\textsuperscript{1,4} and Andrew S. Brierley\textsuperscript{1}

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Robust time-series of jellyfish abundance are unavailable for many ecosystems. This lack of direct observational data leaves it difficult to infer causes (e.g., climate) and consequences (e.g., trophic cascades) of changing jellyfish abundance. We sought an indirect ecological route to reconstruct jellyfish abundance: since zooplankton are jellyfish prey, historic variability in the zooplankton may provide a proxy for jellyfish abundance. We built a Bayesian ecological network of spatial jellyfish-zooplankton dependency using paired jellyfish-abundance data from echosounding and zooplankton-abundance data from nets from a two-week cruise to the Irish Sea in 2008. We then created historic zooplankton networks using abundance data from the Continuous Plankton Recorder from 1970 to 2000. The 2008 jellyfish-zooplankton network revealed that *Aurelia aurita* abundance had a consistent dependency on the plankton community. Inferring historic jellyfish abundances from the CPR zooplankton networks revealed that *Aurelia* abundance was more strongly connected over time to surface sea temperature than to zooplankton. The generalist predatory abilities of *Aurelia* to consume a variety of zooplankton may have insulated it from significant abundance change over the 1985 regime shift. There was no evidence for association between jellyfish abundance and herring abundance, so the fishery curiosity that motivated the study was not fulfilled.
The trophic ecology of *Aurelia coerulea* in a Mediterranean coastal lagoon

**Raquel Marques, Delphine Bonnet, Audrey Darnaude**  
*MARBE, Université de Montpellier, France*

The trophic ecology of jellyfish is still poorly known, particularly at the benthic life stage. With this regard, Thau is one of the rare habitats to harbour a resident population of the scyphozoan *Aurelia coerulea*, where the annual population dynamics of both benthic and pelagic stages have been described. This offers an exceptional framework to understand the possible trophic processes regulating jellyfish populations over time. Moreover, the lagoon supports an important shellfish farming activity, which warns of a potential interspecific trophic competition, especially during the jellyfish bloom. Here, we investigated the sources of organic matter sustaining critical periods of *A. coerulea* population dynamics (e.g. peak of buds’ production, strobilation and medusae growth) and addressed its potential trophic competition with bivalves. For this, we assessed monthly variations in the C and N stable isotope signatures of *A. coerulea* scyphistomae and medusae for one year and compared them to those of their main potential food sources and competitors. Strong temporal changes in the isotopic signature were observed at both stages of the life cycle, revealing shifts of the trophic niche of *A. coerulea* during the year. Interspecific competition for food was low indicating limited impact of the jellyfish on the local shellfish production.
Tiny jellies, big appetite: Population dynamics of hydromedusae in North Inlet Estuary, SC, USA, and their role in regulating estuarine food webs

Joshua Stone¹, Josiah Grzywacz¹, Dennis Allen²

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Hydromedusae (Cnidaria: Hydrozoa) can periodically become very abundant and have significant impacts on food webs within coastal ecosystems. In order to examine the ecological role of hydromedusae in the coastal waters of the Mid-Atlantic Bight, we identified and quantified hydromedusae in biweekly zooplankton tows from North Inlet Estuary, SC over two periods, from 1981-1984 and 2010-2014. Temperature, salinity, and dissolved oxygen data were also collected in conjunction with zooplankton net tows. We identified 11 hydromedusae species present in the samples across the 9 years analyzed. Several species showed strong seasonal patterns in abundance, with some more abundant in warmer, summer months and others in spring or winter. We also observed changes in phenology, as the timing of peak abundance changed between years and there was much greater species diversity in the fall and winter of recent years. During blooms of peak abundance, hydromedusae may graze up to 3 mg C d⁻¹ m⁻³ and could exhibit top-down control of copepods in the estuary during blooms throughout the year. In contrast with other estuarine systems where Scyphozoan jellyfish dominate, hydromedusae are a key predator of zooplankton in North Inlet and should be considered in food-web models of the region.
Predatory babies: the potential of *Pelagia noctiluca* ephyrae feeding on larval tuna

Daniel Ottmann\(^1\), Rosa Balbín\(^1\), Laura Leyva\(^1\), Patricia Reglero\(^1\), A. Gordo\(^1\), Laura Prieto\(^2\), Øyvind Fiksen\(^3\), Diego Álvarez-Berastegui\(^4\)

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The Atlantic bluefin tuna, *Thunnus thynnus* migrate long distances to reproduce in relatively unproductive areas like the offshore waters off the Balearic archipelago in the Mediterranean Sea, where the predatory pressure on eggs and larvae is thought to be low due to a near-absent community of filter-feeding fishes. However, such low predatory pressure remains largely unverified as the effect of planktonic predators like gelatinous organisms has not been quantified. *Pelagia noctiluca* is the most abundant jellyfish in the Mediterranean Sea and remains its entire life cycle in the pelagic environment. Previous research has shown that fish larvae and eggs are important food sources of *P. noctiluca* ephyrae, and we observed up to 73 ephyrae m\(^{-3}\) in the Balearic waters during the tuna spawning season. Here we modeled the distribution of ephyrae and larval tuna and estimated their quantitative overlap in Balearic waters over five spawning seasons. Larvae and ephyrae co-occurred in only 46% of the sampled stations and overlap values were generally low. In the sites where overlap was exceptionally high, ephyrae contained tuna larvae in their gut content. These findings suggest either predator avoidance or prey depletion, highlighting a need to further investigate the predatory potential of ephyrae on larval tuna.
Predation selection and diet of jellyfish *Cyanea nozakii* in the northern East China

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*Cyanea nozakii*, as a common jellyfish distributed in offshore China, has a complex trophic relationship with other zooplankton communities. Predation selection by experimental clearance rate and diet shift by analyzing stable isotope (SI) δ¹³C and δ¹⁵N of *C. nozakii in situ* were conducted in the northern East China Sea (ECS). Clearance rates of *C. nozakii* widely varied with prey organisms. Gelatinous organisms were captured with considerably higher efficiency than copepod and fish. Both size of *C. nozakii* size and prey had marked effects on clearance rate. Predation on prey organisms improved with increasing *C. nozakii* size and decreased with increasing prey size. A significant change in SI values was found during *C. nozakii* growth, including an increase of ~1.93 ‰ in δ¹³C and ~2.23 ‰ in δ¹⁵N. The MixSIAR model indicated that *C. nozakii* underwent a dietary shift during growth, starting from a seston-based diet at the smaller medusa stage to a zooplankton-based diet during the larger medusa stage. Perhaps an increase in the feeding proportion of high trophic zooplankton promoted the enrichment of isotopes δ¹³C and δ¹⁵N. Gelatinous prey organisms represented 13.04% of the smaller *C. nozakii* diet, and 35.18% of larger *C. nozakii*, suggesting that larger *C. nozakii* required more gelatinous prey for growth. The diet of *C. nozakii* was comprised of even 9.54% *Nemopilema nomurai* in the diet of *C. nozakii*. It is indicated that intraguild predation maybe an important trophic relationship among these species in the northern ECS.
Marine endotherms as global predators of jellyfish: from “junk food” to “green tea” hypotheses

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There is growing evidence that jellyfish constitute a regular prey for a wide array of marine endothermic predators. This interaction has been documented across the world’s oceans and using varied techniques, from direct observations to DNA diet analyses and animal-borne video data loggers. Consumption of jellyfish is intriguing in terms of energy reward, given endotherms have relatively high energy demands and jellyfish would provide little energy as prey. Here we present an overview of these cases: we show that many of the intuitive hypotheses commonly raised to explain predation on jellyfish have already been tested, and most of them are unsupported. We emphasize that jellyfish in the predators’ diet are generally non-anomalous (i.e., not reflecting a collapse in the trophic webs), and propose that they might be beneficial to marine endotherms for non-energetic reasons, such as enhancing physiological processes. Changing the “junk-food” hypothesis for a “green tea” framework may thus allow to better understand the widespread predation on jellyfish, although further biochemical analyses are needed to clarify this point.
Ontogenetic shifts in ocean sunfish diet

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Although ocean sunfish have historically been described as obligate gelativeds, recent research has suggested that they have a broad trophic role and undergo a seemingly counter-intuitive life history shift. Specifically, smaller fish feed broadly on high energy-density benthic prey in nearshore environments, before moving offshore as they increase in size, shifting to a diet of predominantly gelatinous taxa. Such new insights have significantly changed our understanding of sunfish ecology, demonstrating a broader and more important ecosystem role than previously known. Considering the ongoing mass bycatch of sunfish, the removal of a wide ranging jellyfish predator may have far-reaching implications in ecosystem functioning and serves to highlight the increasing need for conservation management of this vulnerable group.
Have sunfish benefited from the ‘rise of slime’?

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Recent studies have documented surprisingly high densities of ocean sunfish in the North East Atlantic and have suggested that overfishing and ocean warming have caused elevated jellyfish abundances. As a known predator of jellyfish, ocean sunfish may therefore be used as a global indicator of the ‘rise of slime’. However, to-date, there are no sunfish time series available to support such claims and there is also no evidence of a global increase in jellyfish abundance. Here we analysed a 46-year time series of sunfish sightings collected from a coastal observatory in Ireland from 1971-2017 to address two questions: 1) have sunfish increased over time, and 2) can observed changes in sunfish sightings be related to changes in environmental variables such as wind direction, food availability and sea surface temperature. Indices of sunfish food availability were obtained from the Continuous Plankton Recorder, specifically, only siphonophores were used as their nectophores are reliability identified from the CPR filtering silks and sunfish are known to feed on siphonophores.
Large vertical migrations of *Pyrosoma atlanticum* play an important role in active carbon transport

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Pyrosomes are efficient grazers and re-packagers that can form dense aggregations contributing significantly to the downward carbon flux. In recent years, pyrosome swarms have been found outside of their natural geographical range, however, environmental drivers that promote pyrosome swarms unknown. During the austral spring of 2017, a *Pyrosoma atlanticum* swarm was sampled in the Tasman Sea. Depth stratified sampling during the day and night was used to examine the spatial and vertical distribution of *P. atlanticum* across three eddies. Respiration rate experiments were performed onboard to determine minimum feeding requirements of the pyrosome population. *P. atlanticum* was two orders of magnitude more abundant in the cold core eddy (CCE) compared to both warm core eddies (WCE), with maximum biomass of 360,440 kg WW km⁻³. Pyrosomes exhibited extensive diel vertical migration to a maximum depth of 800 – 1000 m. Active carbon transport in the CCE was four orders of magnitude higher compared to the WCEs. Faecal pellets accounted for ~91% of transport with total downward carbon flux below the mixed layer reaching 11 mg C m⁻² day⁻¹. When abundant, *P. atlanticum* swarms play a major role in active carbon transport, comparable to fluxes of zooplankton and micronekton communities.
Respiratory metabolism analysis in *Aurelia aurita* and *Pelagia noctiluca*

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Studying the respiratory metabolism of jellyfish allows the quantification of their contribution to carbon remineralization rates and their energy production rates. These processes are directly connected with the demand of food and predation rates of these organisms. In this study, we investigated jellyfish respiration using the kinetic enzymatic analysis of the electron transport system (ETS). This enzymatic tool solves some of the logistical problems encountered when capturing and incubating gelatinous zooplankton. The respiratory electron transport system (ETS) activity in two species *Aurelia aurita* and *Pelagia noctiluca* were measured. This ETS activity was stoichiometrically converted to potential respiration (Φ), in oxygen units, and compared with wet biomass (WM) and with traditional physiological respiration (R) determined by optodes. The results were compared with other similar studies. Respiratory carbon demand (RCD) and weight-specific carbon minimum-requirements (WCR) were determined from R and Φ. These carbon-related values were used to analyse predation impact as well as to estimate the global cnidarian respiratory carbon oxidation. Beyond carbon an innovative parameter, heterotrophic energy production (HEP), was also derived from the respiratory measurements. More HEP calculations from respiration would promote energy circulation modelling in ecosystems that would advance understanding traditionally derived from biomass and elemental circulation modelling.
Evidence of nitrification associated with jellyfish

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Nitrogen often represents the limiting element for primary production in the surface ocean and its availability is therefore closely linked to ecosystem productivity. Jellyfish excrete inorganic nitrogen mainly in the form of ammonium, the usually preferentially assimilated form of inorganic nitrogen. Here we demonstrate for the first time the potential of jellyfish-associated microbiomes for nitrification, the stepwise oxidation of ammonia via nitrite to nitrate. Incubations in artificial seawater of three species of jellyfish (*Chrysaora fulgida*, *Chrysaora hysoscella* and *Aurelia aurita*) show substantial rates of nitrification associated with all three species, however the produced forms of inorganic nitrogen differ. Accumulation of nitrite in incubations with *C. fulgida* (1.03±0.02 nmol gWW⁻¹ h⁻¹) indicate the presence of ammonia-oxidizing microorganisms, but the absence of nitrite-oxidizing bacteria. *A. aurita* in contrast appears to harbour both types of nitrifiers, indicated by the accumulation of nitrate (5.43±0.48 nmol gWW⁻¹ h⁻¹), while *C. hysoscella* induces accumulation of both nitrite and nitrate (2.66±0.47 and 10.73±4.28 nmol gWW⁻¹ h⁻¹), suggesting uncoupling of the two steps. Our results suggest that nitrifiers are typically associated with jellyfish but that the composition of the nitrifying community varies. This observation is a major progress in our understanding of the role of jellyfish holobiont in nitrogen cycling.
Respiration rates, metabolic demands and feeding of the rhizostome *Rhopilema nomadica*

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²University of Haifa, Israel

The scyphomedusa *Rhopilema nomadica* (Rhizostomeae, Rhizostomatidae) has been observed in Eastern Mediterranean waters since the early 1980’s. When it occurs in swarms, its predatory impact on the food web is assumed to be great, but this has never been studied. Evaluating its predation pressure on the plankton community, in order to better understand its role in the food web, requires us to gain a better appreciation of its predation potential. Here we present for the first time the results of controlled laboratory respiration and feeding trials, used to measure *R. nomadica*’s metabolic requirements and feeding rates, to assess its predatory impact. Carbon-specific respiration rates and daily carbon turnover calculated for *R. nomadica* were higher than those published for other rhizostomes. Similarly, its ingestion and clearance rates, when fed on *Artemia* sp. nauplii, were considerably high. All experimental medusae consumed carbon much in excess of their body carbon content and metabolic demand. These findings describe *R. nomadica* as an efficient predator, which may well have high feeding rates *in-situ* and when it forms swarms, its trophic impact on natural plankton communities may be tremendous.
Trophic enrichment factors and tissue turnover rates for δ$^{13}$C and δ$^{15}$N in *Aurelia aurita*

Jessica Schaub$^1$, Brian Hunt$^1$, Mackenzie Neale$^2$

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Stable isotope (SI) values of carbon (δ$^{13}$C) and nitrogen (δ$^{15}$N) are commonly used in jellyfish ecology to answer questions about trophic ecology and energy pathways over time. To use isotope models for complex *in situ* data, accurate values for model parameters should ideally be estimated from controlled laboratory studies. For example, trophic enrichments factors (TEF), used to determine the trophic level of an organism, and tissue turnover rates (TTR) can vary depending on the ecosystem, prey δ$^{13}$C and δ$^{15}$N, and the trophic level of the predator. Isotope studies of food webs typically apply generic TEF values to jellyfish, in part because jellyfish-specific values are scarce and unreliable. To address this, we implemented a controlled laboratory feeding study to measure TEF and TTR values for *Aurelia aurita* medusae (T = 10-11°C, S = 28-30 ppt). Medusae were fed *Artemia* sp. nauplii for 24 weeks and subsequently switched to a diet of *Euphausia pacifica* for eight weeks. Medusae and prey were sampled weekly and analyzed for δ$^{13}$C and δ$^{15}$N. Here we present results on TEF and TTR for *A. aurita*. 
Exploring the diversity of microbiota associated with moon jellyfish mucus

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The production and secretion of the protective mucus is an important defence mechanism of many aquatic and terrestrial metazoans. Mucosal surfaces in animals provide critical immunological services by both protecting against invading bacterial pathogens and by supporting large communities of commensal microorganisms. The mucus layers providing interface between epithelial layer of organisms and their external environment have been studied in the bloom-forming moon jellyfish (*Aurelia solida*, Scyphozoa) from the northern Adriatic. Molecular and bacteriological cultivation methods as well as various microscopy techniques (light/epifluorescence and electron microscopy) have confirmed the presence of abundant mucus around polyps and on surfaces of adult medusae. Observed mucus secretions were in form of flocs and considerable amount of various bacterial morphotypes and viruses were embedded in mucus sheets. Microbiota associated with moon jellyfish was different from ambient seawater bacterial assemblage, varied between different body parts and might have an important role for the host. *Betaproteobacteria* (*Burkholderia*, *Cupriavidus* and *Achromobacter*) dominated community in the gastral cavity of medusa, while *Alphaproteobacteria* (*Phaeobacter*, *Ruegeria*) and *Gammaproteobacteria* (*Stenotrophomonas*, *Alteromonas*, *Pseudoalteromonas* and *Vibrio*) prevailed on ‘outer’ body parts.
THE HUMAN-JELLYFISH NEXUS

Humans and jellyfish interact in a number of different ways. Jellyfish may provide ecosystem goods and services, such as food for humans and animals, as well as providing shelter for juvenile fish. Conversely, jellyfish may also negatively affect industries such as tourism, fishing, aquaculture, and power generation. This session will focus on human-jellyfish interactions and potential options to mitigate negative impacts, such as early warning systems.

Conveners:
Rachel Tiller, Angel Yanagihara, Jamileh Javidpour, Angus Bloomfield, Lucas Brotz
Pest and plague or valuable resource and opportunities: Stakeholder perceptions of jellyfish across Europe

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Humans and jellyfish are intricately intertwined in coastal areas around the world, with many species of jellyfish bloom forming, causing challenges to their co-existence. The impacts of these blooms on local stakeholders can include loss of income, hazardous working conditions and more. One of the mitigation options available to combat the negative effects of jellyfish blooms is to transform it from a pest and plague to a valuable resource with economic opportunities instead. The current article explores perceptions of stakeholders from five different European countries (Norway, Germany, Slovenia, Portugal and Israel) regarding the use of jellyfish as a resource as proposed by the H2020 project GoJelly (www.gojelly.eu) based on results of a 7-language questionnaire using SurveyMonkey distributed via social media platforms in the respective countries. Preliminary results from the questionnaire showed that in total, almost 64% of the 837 respondents were positive to using or consuming products made from jellyfish ingredients, and 60% believed jellyfish products could replace other ingredients used today. However, only 15.77% believed that jellyfish represented a new economic resource. These findings are considered in a governance perspective, with an emphasis on coastal zone management and adaptation and mitigation measures available for stakeholders affected by jellyfish blooms.
The cnidome of *Pelagia noctiluca* (Forsskål, 1775) and why you should not use vinegar in case of its sting

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*Pelagia noctiluca* is one of the most important jellyfish on the Mediterranean considering the abundance and severity of its sting. Moreover, its massive arrival to coastal areas generates a negative impact on the health of beach users. Despite these facts, there is a lack of information regarding many aspects of the characteristics of their cnidome and their firing mechanisms, so a greater knowledge is critical to discovering agents to potentially protect against stings and to provide post-sting care. In this study, we analyzed for the first time, the cnidome of this species during the different stages of its life cycle, providing information on the distribution, typology and biometric measurements of its nematocysts. Additionally, we evaluated the response of nematocysts in adult individuals against different compounds, especially vinegar. The use of vinegar as post-sting first aid protocol for jellyfish species is highly debated, as contradicting results have been reported. The nematocyst response to compounds was tested by applying these directly to live tentacles using the Tentacle Solution Assay (TSA) methodology. Surprisingly, the use of vinegar led to the nematocyst discharge and demonstrated the counterproductive effect of its use in case of stings from *P. noctiluca*. 
Protective effect of epigallocatechin-3-gallate (EGCG) on toxic metalloproteinases-mediated skin damage induced by Scyphozoan jellyfish envenomation

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Jellyfish stings are currently raising serious public health concerns around the world. Therefore, the search of novel first-aid reagent suitable for envenomations from wide ranging stinging jellyfish species has become important. Previous in vitro and in vivo reports demonstrated that the metalloproteinase activity of *N. Nomurai* venom (NnV) was the major contributor to envenomation pathology. Therefore, metalloproteinase inhibitors make a promising candidate for the treatment of Scyphozoan jellyfish envenomation. Plant polyphenols have shown potential as treatments for neutralizing snake venoms and toxins. The major polyphenol component in green tea, Epigallocatechin-3-gallate (EGCG), has demonstrated previously metalloproteinase inhibition and we explore its potential as a NnV treatment. We show that EGCG inhibits the proteolytic activity of NnV as demonstrated by gelatin zymography. EGCG reduced NnV induced cell death of human keratinocytes and dermal fibroblasts combined with increased secretion of human matrix metalloproteinase (MMP)-2 and -9. Simulated rate NnV envenomations showed that topical treatments with EGCG significantly ameliorated the progression of the dermonecrotic lesion typically induced by NnV. EGCG also reduced the activities of MMP-2 and MMP-9, which play crucial role in pathogenesis of NnV. Therefore, we proposed that EGCG might be an effective therapeutic agent for the treatment of cutaneous jellyfish symptoms.
Jellyfish venom extraction and delivery in animal models; do we have it right?

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The methods of extraction and use of cnidarian venoms in the literature is wide and quite varied. Venom extraction ranges from blending of entire jellyfish, electrical and or mechanical discharge or disruption of nematocysts, through to chemical induced nematocyst discharge. Application of the extracted venom to animal models can similar vary from intravenous/arterial, intramuscular and/or intraperitoneal and subcutaneous injection. Little if any data exists that compares and/or contrast these different techniques with what occurs in an envenomed victim or prey item. Given the diversity of the venom extraction and delivery modes that exist and are used, and the variation in venoms with in single species of jellyfish (due, for example, to ontogenetic, geographic or seasonal factors) it is perhaps not surprising that the only real consistency in the results from jellyfish envenomed animal models is their inconstancy. In this presentation we compare venom extracted (via mechanical nematocyst disruption and the application of tentacles and/or bells directly to the test animal) from two species of cubozoans, *Chironex fleckeri* and *Carukia barnesi* and compare these results seen in human envenomings.
Preliminary studies to improve outcomes of box jellyfish sting injuries in the Indo-Pacific

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Throughout the Indo-Pacific, multiple species of box jellyfish present life-threatening hazards. While deaths due to box jellyfish stings occur in coastal Australia, Thailand, Indonesia and Malaysia, evidence suggests that the greatest sting-related loss of life occurs in the Philippines where while sting incidence and prevalence have never been systematically assessed, case reports demonstrate that childhood deaths and injuries due to chirodropid box jellyfish stings represent a critical and currently unmet health challenge. Underlying this challenge is the fact that box jellyfish sting incidents and fatalities, are considered “environmental accidents” and not documented in regional and provincial health records. Preliminary pilot study efforts in 2016–2019 in the Philippines demonstrated that the burden of these stings represents an area of serious concern to coastal communities with highest impacts on children and fisher folk in already marginalized areas (estimated at over 100 deaths/year). This is likely the result of the abundance of these lethal stingers and the maritime nature of this island nation, as well as challenges in remote coastal community access to emergent care. Study results will be presented related to the three main aims of this pilot study: 1) public health outreach; 2) field ecology surveys; and 3) bioactivity assays.
Jellyfish blooms in India: ecosystem implications and socio-economic concerns

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Increase in jellyfish blooms is a global concern and in emerging economies like India, it impacts fisheries and aquaculture production, number of fishing days, tourism industry, operation of thermal plants, and aesthetics of ecosystems. The absence of species-specific data on jellyfish landing notwithstanding, the export of jellyfish from India during 1995 to 2018 showed greater fluctuations, with a peak of 6424 million tons in 2003-2004; during 2010 to 2018 India exported a total of 9915 million tons, worth 26 million US$. Nine scyphozoan jellyfish species, *Cyanea nozakii, Chrysaora caliparea, Pelagia noctiluca, Netrostoma coerulescens, Crambionella orsini, Acromitus flagellatus, Lobonema smithii, Lychnorhiza malayensis* and one cubozoan *Chiropsoides buitendijki*, form distinct blooms along Indian coastal waters. In the west coast of India majority of blooms occur towards the end of the southwest monsoon (June to September), while blooms of *Crambionella orsini* starts towards the end of monsoon last till post-monsoon (October-January). *Acromitus flagellatus* blooms occurs in backwaters and estuaries during November to May every year, which coincides with the summer season. Monsoon, upwelling, salinity, plankton abundance, temperature and current patterns trigger the cycles of blooms and movement patterns. Eutrophication, fishing down the food web, coastal development and protection activities coupled with climate-induced changes in hydrography could facilitate proliferation of the blooms. The ecosystem implications of blooms and the socio-economic paradigms while the major species show a decline, are discussed in the framework of long-term and sustainable management strategies.
The race for jellyfish: winners and losers in Mexico’s Gulf of California

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The trajectory of the jellyfish fishery in the central portion of Mexico’s Gulf of California is an all too familiar one, consisting of exploration, rapid development, and subsequent collapse. More recently, fishing for jellyfish has shifted to the northern Gulf, including inside of the Upper Gulf of California and Colorado River Delta Biosphere Reserve. There are always myriad challenges when attempting to manage an emerging fishery with high uncertainty in a developing country; however, this particular narrative underlines the fact that without implementing precautionary measures, resource extraction is inherently unsustainable. While scant data and lack of knowledge are often used as excuses for overexploitation after the fact, this case of a nascent modern fishery demonstrates that no amount of research can substitute for deficient implementation capacity and disregard by policy makers. Unfortunately, recommendations based on sound science were not followed and the precautionary approach was not applied. The resultant paucity of regulation, policy, cooperation, compliance, and enforcement has resulted in the mismanagement of a potentially lucrative fishery for future generations.
Interactions between jellyfish and finfish aquaculture: current mitigation strategies

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Interactions between jellyfish and finfish aquaculture are overwhelmingly negative, usually resulting in increased morbidity and/or mortality of fish in sea cages. Historically, the problem has revolved around salmonid farming in northwest Europe, however, recent work has revealed similar interactions in other species in the Mediterranean. Furthermore, projected increases in global finfish aquaculture suggest that these interactions will not become any less prominent in the future. Managing and mitigating against potentially harmful species currently seems like an intractable problem, however, sustained sampling and research efforts can reveal important ecological insights which can support the aquaculture industry. Here, we review research efforts in Ireland which show that seasonal frontal systems influence the spatial distribution of jellyfish communities. In addition, wind driven exchange of water masses in coastal bays is linked to increases in jellyfish abundance and fish mortalities. Understanding these mechanisms offers a potentially predictive model. Tests of a bubble curtain as a potential barrier systems were challenging in the field, however, flume tanks tests did indicate that this system has potential where wave energy is low. At present, mitigation against jellyfish is largely reactive, however, relatively minor changes to current farm practises have the potential to result in proactive management.
MedusApp, a citizen science tool for monitoring jellyfish populations and stings

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Jellyfish stings represents around 72% of total of injuries attended in beach lifeguard stations in Spanish Mediterranean. However, little quantitative information is offered about the presence of these stinging animals. The main focus of MedusApp was the creation of a simple citizen science mobile application and a webpage (www.medusapp.net) to obtain valid information on abundance and species composition of jellyfish with a double goal: first, provide semiquantitative data for scientific use (sightings for population analysis and stings data for medical use) and second, offer an open database with validated sightings. MedusApp was launched in early 2018 and has around 70,000 installations and near 1,000 certified sightings and 450 stings reported. Sightings analysis showed that Pelagia noctiluca was the most abundant species, SE of Spain, coinciding with a large upwelling event in the strait of Gibraltar in July. The analysis of more relevant envenomations allowed us to detect sensitive patients and get insight into health threats. Citizen science proved to be crucial in providing new information on the spatial and temporal trends of jellyfish and health risks at scales previously unimaginable. This will ultimately allow us to come up with the best possible management policies to minimise jellyfish interactions with humans.
Towards an early warning system for jellyfish blooms

Angus Bloomfield, Hugo Winter
EDF Energy, R&D UK Centre, UK

EDF Energy R&D UK Centre is currently working on developing an early warning system for jellyfish blooms. Various different scientific approaches have been investigated including habitat modelling, hydrodynamic modelling, and the development of automated recognition systems using machine-learning algorithms. These have been applied using a range of different technologies including satellites, drones, and seafloor-mounted sonar. The ultimate system may involve a number of different approaches and technologies, applied at different scales and resolutions. However, it is recognised that none of the current approaches may yield a practical solution.
More than 10 years dealing with jellyfish blooms: the jellyfish observation network in the NW Mediterranean

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Due to the few long-time series on jellyfish presence in coastal areas around the world, it is not easy to clarify if jellyfish blooms are increasing or not, however the negative interaction between these animals and human activities are well known. Along the Catalan coast (NW Mediterranean) an established Jellyfish Observation Network (JON) formed by trained personnel from rescue services have been recording jellyfish data and other incidences (jellyfish stings) in a real-time daily basis for more than 10 years. The permanent presence of the JON on the beaches has allowed us to analyse jellyfish (Pelagia noctiluca and Rhizostoma pulmo) trends, ensuring high quality of the data due to the permanent training and the direct contact maintained with each lifeguard team. Herein we present a novel approach to the understanding of jellyfish blooms historical data and management plans, analysing more than 10 years of jellyfish presence, including more than 200 beaches along the Catalan coast during the summer season. In addition to innovative management plans (iMedJelly) we’ve been able to validate and update information in real time and provide prevention and support tools (warning and sting protocols) for administrations and citizens in general as society’s pay wards.
Progress on the disaster prevention & mitigation strategy, equipment development for emergency disposal of Jellyfish Bloom in China coastal waters

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Since the beginning of the 21st century, the Chinese coastal sea has suffered from jellyfish blooms, which are considered to be among the most serious ecological disasters, impacting the marine ecosystem, environmental safety, and the development of the maritime economy. As a national key R&D plan, the forming mechanism, monitoring, prediction, evaluation and control technology of Jellyfish Bloom in China coastal waters led by Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China, named as “China Jellyfish Project II” was endorsed in July 2017, which was the successional program of “China Jellyfish Project”. This project will aim to establish the comprehensive prevention and control system for monitoring, early warning and deal with, serve for government general management and control and emergency decision. This study will give a brief introduction on a part of progress of this project on the disaster prevention & mitigation strategy, equipment development for emergency disposal. The possible biological competition mechanism of jellyfish, the human-control changed drifting path of the disaster causing species by flent modelling and the development of automated cleaning equipment will be presented.
Precautionary management of jellyfish bloom by polyp elimination

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Aurelia coerulea is designated as a harmful marine organism defined to be managed by the act on “Conservation and Management of Marine Ecosystem” in Korea. Young polyps of jellyfish among its life cycle are important reservoir contributing to medusa blooms. Thus, we adopted the precautionary approach by implementing “Jellyfish Polyp Management Program” since 2013. Ephyrae were significantly decreased after polyp elimination in all areas where we pinpointed exact locations of the polyp. Medusae have been captured little by plankton net or not observed since the polyp-removal. Downsizing of jellyfish populations by polyp elimination has been successful in most cases; however, durability to suppress the re-growth of polyp population and medusa blooms were different between areas provably because of inflow of matured females producing new planulae, originated from neighboring or distant polyp populations. We are going to discuss effectiveness of direct elimination of polyp as a countermeasure of jellyfish bloom.
The microstructure of jellyfish mesoglea and jellyfish chips

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Jellyfish are of gastronomic interest – in Asian cuisine, where jellyfish has been eaten as a tasteless but crunchy delicacy for more than 1000 years, as well as in Western cuisine, where the search for sustainable food resources and unique food experiences has pointed to jellyfish as a potential candidate. Transforming a soft jelly substance into food of gastronomic value requires insight to the molecular organisation and structural integrity of the jellyfish mesoglea in order to choose an appropriate cooking technique. Here, we describe the jellyfish mesoglea as a charged polymer gel that will swell and collapse as a function of the ionic strength and the quality of the solvent. We further present two-photon fluorescence microscopy images to visualise the filamentous network constituting the jellyfish mesoglea in live anesthetised jellyfish (Aurelia aurita). A network that undergo significant physical rearrangements when prepared for food by traditional Asian means using NaCl and Alum giving a crunchy texture, and by a novel preparation using EtOH transforming the jellyfish to crispy chips. The latter being a potential new gastronomic treat.
Are farmed fish hungry for jellyfish? - The potential of jellyfish as alternative source of proteins in fish feed

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Farmed fish production has outpaced wild capture fisheries in seafood destined for human consumption and aquaculture now supplies around half of the fish consumed directly by humans. The rapid growth of aquaculture has led to an increasing demand for fishmeal and fish oil. In 2016, almost 12% of the total fish production was reduced into these two raw materials, raising concerns about the long-term sustainability of the industry. Consequently, substantial effort has been expended over the past decades in evaluating a wide range of potential alternatives. In this regard, we determined the biochemical composition (elemental analysis (C, N and P) and biochemical analysis (total protein and lipid content, and amino and fatty acid profiles)) of four native Scyphomedusae (Aurelia sp., Cotylorhiza tuberculata, Pelagia noctiluca and Rhizostoma pulmo), one Hydromedusa (Aequorea forskalea), and an invasive non-native ctenophore (Mnemiopsis leidyi), and evaluated the potential of utilizing this protein-rich gelatinous biomass as alternative resource in feed in sustainable culturing of the European bass (Dicentrarchus labrax). In addition, we tested a simple and cost-effective approach that uses jellyfish physiological ability of osmoregulation to desalinate the biomass and increase the application possibilities and its industrial value.
Biotechnological applications of scyphomedusae

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Stazione Zoologica Anton Dohrn Napoli, Italy

Jellyfish, particularly scyphomedusae, have been considered as a nuisance for their interference with human activities along the coast (tourism, industry, fishery). Additionally, the apparent increase in the frequency of jellyfish outbreaks has made the perception of these organisms even more negative. In contrast with this negative view, recent studies have highlighted that scyphomedusae (Cnidaria, Scyphozoa) synthesise at least three main categories of compounds that may find biotechnological applications: collagen, fatty acids and components of crude venom. The current biotechnological applications of scyphomedusae fall mainly into four categories of products: nutraceuticals, cosmeceuticals, biomedicals, and biomaterials. Because people across the world live longer, chronic diseases and diminished well-being are becoming major global public challenges. The overexploitation of several resources is forcing to search for new sources of bioactive compounds and new compounds themselves. By defining the state of the art of biotechnological applications in scyphomedusae, we intend to contribute to changing the paradigm “jellyfish=pest” and promote the use of the bioactive compounds extracted from them to reduce the overexploitation of some resources and increase the well-being of future societies.
Sea Jellies Illuminated: partnering with Sea World to deliver a state-of-the-art jellyfish research laboratory that engages the public in jellyfish science

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¹Griffith University, Australia
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Embedding a jellyfish research laboratory within a public oceanarium is a unique way to deliver world-class research infrastructure and engage the public in jellyfish science. In 2018, Griffith University partnered with Sea World to develop 'Sea Jellies Illuminated', a combined jellyfish exhibit and state-of-the-art jellyfish research laboratory, located within the Gold Coast's iconic Sea World oceanarium. The laboratory contains a wet-lab housing 48 experimental kreisels and water tables for culturing polyps, and a dry-lab. The glass walls of the laboratory enable the ~1.2 million people who visit Sea World each year to watch jellyfish research being done. The visitor's area outside the laboratory is equipped with digital interactive displays that interpret the research and educate visitors about jellyfish and the marine environment. Our partnership is delivering mutual benefits. Griffith University benefits from access to world-class research facilities, prominent exposure of the Griffith brand and the opportunity to engage the public in science. Partnering with Griffith University has provided Sea World with a profitable new exhibit, credibility for the research it supports, and ready access to scientific expertise. The partnership between Griffith University and Sea World is a fantastic example of the synergies that can exist between universities and industry.
NOVEL TECHNIQUES FOR UNDERSTANDING THE ECOLOGY OF GELATINOUS ZOOPLANKTON BLOOMS

Gelatinous zooplankton play important roles in marine food webs, including fisheries. They are efficient grazers, compete with fish for food and feed directly on larval fish. When abundant, gelatinous zooplankton also play major roles in biogeochemical cycling through vertical transport of carbon to depth. To effectively comprehend these ecosystem interactions, we require improved understanding of abundances, diversity, dynamics and biogeography of gelatinous zooplankton blooms. This session examines processes influencing population dynamics, including spatial distributions, population connectivity, habitat suitability, adaptability in diverse ecosystems and trophic interactions. New techniques, such as, in-situ visualization, microbiomes, genetics, and modeling will be showcased.

Conveners:
Dror Angel, Natasha Henschke, Mary Beth Decker, Evgeny A. Pakhomov, Cornelia Jaspers
How do we quantify the abundances of something as elusive as jellyfish?

Dror Angel  
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Quantifying marine biota is often challenging when we consider the factors that disperse these and the 3-dimensional realm that they inhabit. In addition to ocean hydrodynamics that either concentrate or distribute organisms, the complex swimming behavior exhibited by jellyfish challenges our abilities to enumerate them, often making our estimates of their abundances inaccurate. It is the highly variable nature of jellyfish distribution that makes their sampling with nets inefficient unless we know where and at what depth they occur. Many estimates of jellyfish numbers are based on surface counts, performed by direct counts from boats, drone or aerial photography, etc. but these are just the surface features of populations distributed in 3D. Sonar and underwater quantification methods have been used to improve our estimates, but each method has its drawbacks. This presentation will focus on current and future technologies for deriving numbers for the abundances of jellyfish, at the surface, near the seafloor, in shallow and in deep sea environments.
Chrysaora melanaster spatial and seasonal dynamics detected by Adaptive Resolution Imaging Sonar (ARIS) in the eastern Bering Sea

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Scyphozoan jellyfish are conspicuous components of marine ecosystems and when they bloom, they have the potential to affect food web structure and fisheries. In the eastern Bering Sea (EBS), jellyfish biomass, primarily Chrysaora melanaster, has varied widely over the past four decades, yet the direct causes of these fluctuations remain unclear. We investigated the spatial and seasonal dynamics of EBS C. melanaster using Adaptive Resolution Imaging Sonar (ARIS) and nets in June-July and September, 2018. The mean abundance detected by ARIS was similar in early and late summer (0.78×10⁻² and 0.77×10⁻² ind m⁻³, respectively), and was comparable to that estimated by plankton nets. C. melanaster spatial distribution was also similar between study periods, with peak abundances found along Alaska Peninsula coast (3.1×10⁻² and 2.7×10⁻² ind m⁻³ respectively). High abundances were associated with a frontal zone, where Alaska coastal waters and the Aleutian North Slope Current intersect. C. melanaster occurred at all depths throughout the water column during both day and night sampling. Our results indicate that spatial dynamics of C. melanaster are driven by hydrography and interactions between water masses on the EBS shelf. We hypothesize that frontal processes may transport medusae away from the coast and across the shelf.
Validation of Environmental DNA, eDNA, as a method of detection for the cubozoan, *Copula sivickisi*

**Brett Bolte, Dean Jerry, Roger Heurlimann, Julie Goldsbury, Michael Kingsford**  
*James Cook University, Australia*

Understanding the ecology of cubozoan jellyfish has been hampered by high spatial and temporal variation in abundance. Environmental DNA (eDNA) has the potential to detect the present and absence of polyps and medusae and possibly give some indication of abundance. Here, using a section of the 16S gene, we developed the first primers for the cubozoan, *Copula sivickisi* and two other species, *Carybdea xaymacana* and *Carukia barnesi*. Our species-specific primers, allowed for reliable detection of *Copula sivickisi* medusae in the wild. Field collections of *Copula medusae* were conducted in the waters of Magnetic Island, North Queensland in the Australian spring (September-November). We tested the following hypotheses; (1) eDNA would be detectable on a scale of days after the sources of jellyfish was experimentally removed; (2) eDNA quantity would increase with the known number of jellyfish in the laboratory and the field; (3) if polyps can be detected with eDNA then that should be possible in the absence of medusae. Using the reliable species-specific primers, DNA extracted from water samples were run through qPCR to determine the presence and quantity of DNA in the sample. We conclude that eDNA, is a viable method of the detection of different life history stages of cubozoans.
A novel platform for monitoring small gelatinous zooplankton: the high-speed Gulf VII plankton sampler captures gelatinous meso-zooplankton as effectively as a traditional ring net

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Although methods for sampling gelatinous zooplankton (within the phyla Chordata, Ctenophora and Cnidaria) have improved over the past 20 years, there is still no dedicated monitoring of pelagic gelatinous meso-zooplankton in northeast Atlantic waters. A potential new source of gelatinous meso-zooplankton data is from ICES triennial Mackerel Egg surveys, which use a high-speed Gulf VII sampler to collect meso-zooplankton samples in European shelf waters. To evaluate the Gulf VII sampler for sampling gelatinous meso-zooplankton, this study collected zooplankton samples using both the Gulf VII sampler and a vertical ring net at 15 stations off the Irish and Scottish coasts in July 2017. Results indicated that mean gelatinous zooplankton abundance (Gulf VII = 139 ind. m⁻³, ring net = 155 ind. m⁻³) and the mean taxon richness (Gulf VII = 15.2, ring net = 15.4) between the two sampling nets were very similar with no significant differences between the two nets (ANOSIM; r = - 0.008, p = 0.469). Considering the lack of long-term broad-scale gelatinous zooplankton monitoring in European waters, our findings suggest that the ICES Mackerel Egg surveys should be used to monitor gelatinous meso-zooplankton both in the past (by re-examining historical samples) and into the future.
Combining UAVs and AI: producing an early warning system for coastal industries

Ben Mcilwaine
Cranfield University, UK

Jellyfish blooms are an ever-present threat faced by coastal operators worldwide. From decimation of fishery stocks, to power generation losses at coastal nuclear power stations, large aggregations of jellyfish are a source of significant human-wildlife conflict. To combat this growing risk, we are utilising UAVs in a remote sensing configuration to overcome the limitations of current detection techniques. Using the images collected of *Aurelia aurita* blooms from UAV flights, the imagery has been processed using machine learning techniques: a swiftly developing field within artificial intelligence. Through the application of convolutional neural networks and the detection of jellyfish within UAV aerial imagery, we are moving towards the deployment of an early warning detection system for disruptive events. Our aim is to help warn coastal operators of approaching blooms and is the next step in our delivery of a comprehensive marine ingress warning system.
State-of-the-art technologies to study *Pelagia noctiluca* in the Balearic Sea (Mediterranean Sea)

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The aim of this study is to combine the abundance variability of jellyfish with the physical and oceanographic forcing at different spatial and temporal scales in the Balearic Sea. The most abundant and frequent species in this area but also in the whole Mediterranean Basin is *Pelagia noctiluca*. This species is totally pelagic during its entire life cycle as it lacks the polyp stage. Another peculiarity of *P. noctiluca* is that does dial vertical migration: surface at night and 80-100m during the day. For this ecology study of *P. noctiluca* multi-diverse technologies were employed: plankton nets, ROVs, CTDs, cameras equipped with laser (to study jellyfish abundance day and night), Lagrangian buoys, drones, several remote sensing images and hydrodynamical models, together with a jellyfish observation system implemented in the shoreline and continental shelf. The complete study demanded the use of both, an oceanography vessel with 24 h operability and also a big data assimilation facility. The combination of all these sources of data was analyzed to characterize this jellyfish variability and its connection with the physical environment at a resolution never achieved before.
Spatial shifts of major gelatinous and crustacean metazoans in response to projected climate change scenarios

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Shift in distribution is a well-known species response to climate fluctuations in the ocean. This response widely documented for marine species in the context of climate change. While it may be possible for tropical and temperate species, in polar regions species face a rapid contraction of their geographical range as well as new challenges associated with coastal environments. Circum-Antarctic habitats of the pelagic tunicate, Salpa thompsoni, and Antarctic krill, Euphausia superba, were modelled using presence only environmental niche and diffusion models addressing large- and fine- scale distributions, respectively. An ensemble suite of models was used to project habitat shifts of both species and their potential contemporary and future overlap under two RCP scenarios. Both species showed a southward shift in distribution under climate change, which was most profound under the “business-as-usual” scenario. Projections demonstrated that since the 1950s the overlap between species’ habitat increased and stabilized. Further climate change is likely to lead to a persistent habitat overlap, with a potential increase in both inter-species interactions and competition for limited space. At the fine-scale, however, species may show a reduced overlap due to their differing ecology. Potential “winners” and “losers” and implications for the high Antarctic ecosystem functioning are discussed.
Is phenotypic plasticity determined by temperature and fluid regime in scyphomedusae?

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We cultivated two scyphomedusae species, \textit{Lychnorhiza lucerna} and \textit{Cassiopea andromeda}, in different temperatures to investigate if variations in physical environment could trigger compensatory mechanisms, like the development of functional dimensions of feeding structures. Bell and oral arms filtering structures (digitata) were measured and compared among treatments. Ephyrae at lower temperatures filled the umbrella margin slower, developed smaller bells, and longer, more spaced and thicker digitata. At lower temperatures, the thickness of the boundary layer around the digitata and the umbrella marginal lobes increases as the fluid viscosity increases. Therefore, neighboring filtering structures could operate as a continuous structure, due to the overlap of their surrounding boundary layers. These possible overlaps of the boundary layers around consecutive digitata could reduce the flow between these collecting structures and hinder particle filtration. We observed a temperature-induced morphological development of the digitata that may compensate for potential boundary-layer overlapping effects. Scyphomedusae proved to be resilient to different developmental temperatures, and exhibited growth patterns that maintained the functionality of the swimming and feeding structures. These results suggest that the phenotypic plasticity is a compensatory response mechanism during jellyfish development to thrive in a wide range of temperatures and physical environments.
*Pelagia noctiluca* ephyrae from NW Mediterranean Sea: where are they before becoming medusae?

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The scyphozoan *Pelagia noctiluca* (Forsskål, 1775) is the most common and widely distributed jellyfish in the Mediterranean Sea. Also, and because of its predatory effects on zooplankton community and its interactions with human activities, it is usually considered the most important jellyfish in Mediterranean waters. The ecology of adult medusae has been extensively studied. Contrariwise, due to the holoplanktonic life cycle (i.e. lack of benthonic stage) allowing its reproduction offshore, basic ecological knowledge about their larval stages (i.e. ephyrae) remains scarce. Therefore, insights about its ephyrae distribution and ecology would contribute to better understand the general ecology of the species. This work is focused on summer distribution (July-August 2016) of *P. noctiluca* ephyrae collected offshore at 75 stations within a large-scale sampling in the NW Mediterranean (CONECTA project). Regarding their horizontal distribution, the ephyrae were absent at the north of the study area, probably because of cold waters inflow from the Gulf of Lions by the Northern Current. At the south of the sampling area, the entering flow of the Atlantic Ocean waters would explain the higher abundances detected. Regarding vertical distribution, they are located between surface and 50m, above the pycnocline, with similar abundances at 0-25m and 25-50m depth.
Ecology and population connectivity of the cubozoan *Copula sivickisi* in northern Australia

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The cubozoan, *Copula sivickisi*, has a cosmopolitan distribution. However, here we present ecological data and biophysical modelling to demonstrate that local populations of this species can be very restricted and, connectivity among populations is limited. Medusae of *C. sivickisi* are found over a 2.5 months season in northern Australia and daily increments in statoliths indicate a maximum age of 85 days. Data from underwater ‘jellycams’ and plankton samples demonstrated that medusae prefer shallow water (< 6m), especially where algal *Sargassum* beds are present. Diel behavioural data we collected on swimming speeds, feeding and responses to benthic habitats were included in a biophysical model. Oceanographic parameters in the model were calibrated with field measurements around Magnetic Island, North Queensland, Australia. At small spatial scales (<2 km) a high proportion of medusae (> 20%) were close to natal habitat after one month. Connectivity among sites separated by 1-10 km was low and advection of medusae over the 10 km distance to the mainland was very low. The potential for insipient speciation in this species is high. Dispersal, therefore, is weak and the historic expansion of the population was probably low and perhaps assisted by plate tectonics.
Population structuring of *Chrysaora africana* and *Chrysaora fulgida* across the west coast of Africa

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Recent work by Abboud et al. (2018) has suggested that, within Large Marine Ecosystems (LMEs), “meroplanktonic species [of jellyfish] are often genetically structured on scales of 10s to 100s of km”. These authors further suggest that “more accurate descriptions of genetic and geographic differentiation are crucial”, if we are to understand the blooming nature of many jellyfish. Unfortunately, Africa as a whole was not considered in the analyses of Abboud et al. (2018), and we partially redress that issue here — insofar as the Atlantic coast of the continent is concerned. The genus *Chrysaora* is represented by two recognised species off the west coast of Africa. *Chrysaora fulgida* is a bloom-forming species that occurs from southern Angola to the SW Cape in South Africa and it can be thought of as a Benguela endemic. By contrast, *Chrysaora africana*, a non-blooming species, is found from southern Namibia to the Gulf of Guinea. Here we investigate the morphological and genetic structure of populations of these two species in order to compare observations with Abboud et al. (2018).
Causes and consequences of the great pyrosome bloom in the Northern California Current

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Of the pelagic urochordates, salps and appendicularians are dominant components of oceanic, low productivity waters globally and have been studied with some regularity in many ecosystems. In contrast, colonial pyrosmes are generally restricted to tropical seas and have been far less studied. *Pyrosoma atlanticum* has periodically been recorded off Southern California, but during the recent anomalously warm conditions in the Central North Pacific that began in 2014, the colonial pyrosome started appearing north of its known latitudinal range in coastal trawl surveys off Oregon and Washington. Over the next five years, the species increased dramatically in abundance, becoming the dominant component of pelagic surveys in 2017 and 2018, and then retreated to southern waters in 2019. The massive blooms impaired commercial fisheries and washed up on beaches prompting public concerns. Due to the paucity of information on this species outside its normal range, we examined horizontal and vertical distribution, habitat preferences, energy density, diets based on fatty acid and stable isotopic signatures, grazing rates, and utilization by higher trophic levels. Since this tropical invader may become established in this productive temperate ecosystem, understanding its ecology and potential impacts to the pelagic and benthic food webs and human utilization is critical.
Modeling *Pelagia noctiluca* dynamics in the Mediterranean Sea

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In the Mediterranean Sea, most jellyfish outbreaks are caused by *Pelagia noctiluca*, but its abundance and biomass remain non-quantified so far, as well as its impact on zooplankton. Here we use a Lagrangian-Dynamic Energy Budget (DEB) model to study the dynamics of *Pelagia noctiluca* in the Mediterranean Sea. Each jellyfish-particle is constrained (offline forcing) by temperature and zooplankton prey fields taken from a coupled physical-biogeochemical model, while drifting with currents and migrating vertically. The DEB model was calibrated to represent the seasonal increase in bell diameter observed in the Ligurian Sea. Then particle ensemble simulations were run to map the size, egg production and energy reserve of jellyfish for the Mediterranean basin over a full annual cycle. While jellyfish tend to aggregate in quasi-permanent gyres (mostly in the Tyrrhenian, Ionian and Gulf of Sirte), large diameters were simulated close to the most productive areas (Alboran Sea, Northwestern gyre, Adriatic, and Northern Aegean Sea). Coupling these results with *in-situ* data of biomass, the jellyfish biomass distribution and impact on zooplankton can be estimated for the whole basin for the first time. The sensitivity of the results to fluctuations of prey availability and temperature is discussed.
Using citizen science, at-sea observations and a Lagrangian particle-tracking model to determine the source of a Portuguese Man O’ War Physalia physalis (Hydrozoa: Siphonophorae) mass stranding event

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Many marine animals remain elusive and are understudied because they are widely dispersed across oceans, appear episodically in nature and are not captured by traditional sampling methodologies such as fishery surveys. A case in point is the Portuguese Man O’ War Physalia physalis (Linnæus, 1758), which despite being pleustonic and remarkably conspicuous, is one of the least studied and understood gelatinous zooplankton species. During August to October 2016, over 100 citizen science records representing more than 1,900 individual P. physalis were collected from around the Irish coastline. The maximum density recorded was 1100 indiv. /km of coastline. During August and September, visual observations of P. physalis were made from a ship of opportunity in the Porcupine Seabight, allowing unique “at-sea” observations of P. physalis to be made prior to and during a mass stranding event. A total of 16 ship transects were carried out over an area extent of approximately 3,800 km², with 139 individual colonies observed and highest densities of 10.29 indiv. /km² recorded. To better understand stranding events, a Lagrangian particle-tracking model, given the initial locations and densities of colonies, was used to simulate the advection of individual organisms. The model successfully replicated the temporal pattern of actual strandings with an accuracy of 80% and results strongly suggest that P. physalis strandings from around the Irish coastline originated from a local population (estimated densities of 5.38 indiv. /km²) in the Porcupine Seabight, where the “at-sea” observations were initially made, rather than a much larger population in a wide area encompassing the Celtic Sea approaches.
Quorum sensing and abiotic factors underlying bloom potential in *Mnemiopsis*: new evidence from laboratory culture

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The ctenophore *Mnemiopsis leidyi* is a widely recognized bloom-forming species native to Western Atlantic coastal waters. Its opportunistic feeding, high ingestion rates, wide tolerance to environmental conditions, high fecundity, short generation times and the capacity for self-fertilization make it an extraordinarily successful invader. Previous studies have provided valuable data on the abundance and distribution of *M. leidyi*, but seldom incorporated experimental approaches to population dynamics. Therefore, the drivers of *M. leidyi* blooms are still unknown. Laboratory culture offers an excellent opportunity to evaluate a wide array of factors in a controlled environment. Our setup allowed us to establish a permanent multi-generation culture, and to test a set of factors that potentially induce larger offspring. The results show significantly larger larvae production when the parental generation is submitted to higher temperature, lower salinity or warm light colour temperature. In addition, we report a negative correlation between density of reproductive individuals and number of larvae produced, thus confirming the role of signalling in spawning. The outcomes constitute a complementary line of evidence of the drivers shaping bloom occurrence in *M. leidyi*, and provide an experimental framework that can also be applied to other blooming gelatinous zooplankton.
What is the *Aurelia* from Mozambique?

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Our understanding of the biology of Scyphozoa is firmly rooted in one genus: *Aurelia*. WORMS recognises nine valid species of *Aurelia*, though over the last decade, molecular studies have shown that there may be between 13 and 16 species. The genus is characterised by crypsis and many species are much more locally restricted than originally thought. Few species are recognised south of the equator and none has been subject to modern description. During a survey conducted off East Africa in 2018, large populations of an *Aurelia* species were observed off northern Mozambique in the Western Indian Ocean. Samples were collected, and they are analysed here using a combination of morphometric and molecular techniques.
Rethinking environmental factors in determining moon jelly’s life history: the importance of food quality

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Understanding the interaction between organisms’ life history traits and environmental factors is an essential task in ecology. To investigate survival, growth, and phase transition of Aurelia aurita polyps, we designed a factorial experiment manipulating food quantity, food quality (Artemia salina and two dietary manipulated Acartia tonsa), and temperature (13 °C, 20 °C, and 27 °C). In this experiment, highly unsaturated FA (HUFA) was used as the food quality indicator. Newly hatched A. salina nauplii were almost devoid of HUFA. In contrast, A. tonsa contained more HUFA. Our results show that temperature was the key factor determining phase transition of polyps. Interestingly, polyps fed with food containing high level HUFA were able to compensate for physiological stress caused by the extreme temperature and could enhance budding reproduction at the optimum temperature (up to ca. 34.5%). Moreover, strobilation was determined by temperature but affected significantly by food conditions. We suggest a novel polyp tolerance curve, which can help to understand jellyfish population dynamics in different seasons and ecosystems. This sets up a baseline for understanding how anticipated global warming and food conditions may affect the population size of benthic polyps and consequently pelagic medusae.
Effects of temperature shifts on strobilation

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Strobilation is influenced by a combination of different factors among which temperature plays a major role. Yet, the way that strobilation is controlled by temperature shows considerable variations between species/lineages, sites/locations, and even within the same populations. In addition to this natural variability, the diversity of utilized methodologies has been highly diverse hindering the comparison of results. Unless the strobilation is studied under a common methodology, the distinction between the effect the natural and artificial variability will keep faint. Therefore, we tested an experimental protocol to study the temperature effects on strobilation that would allow replication and comparison of results between laboratories. Through this protocol, we investigated the effects of temperature-change schedules on the strobilation of four scyphistomae species. We observed that strobilation is triggered by a set of different factors among which temperature shifts play a key role in all the studied species. However, specific responses vary among them. Strobilation was triggered by temperature increases and inhibited by temperature drops in Lychnorhiza lucerna, Stomolophus meleagris, and Cephea cephea. Conversely, temperature drops induced strobilation in Aurelia coerulea. Finally, we suggest that the identification of the factors regulating strobilation rates could be split into the inducing factors, the inhibiting ones, and those that control the number of ephyrae produced.
Environmental forcing in early life stages of the scyphozoan jellyfish *Rhizostoma luteum*

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It is important to understand the role of early life stages in the formation of jellyfish outbreaks, whether they are cyclic or in response to climate change, and it has been neglected until recently. The aim of this study was to determine the response to environmental forcing in the early life stages of the scyphozoan jellyfish *Rhizostoma luteum*. Laboratory experiments were carried out to examine the effects of different temperature and salinity conditions on planula settlement, scyphistoma development, podocyst production, ephyra liberation and development until the metaephyra stage. The results show that the planuiae were highly resilient to a wide thermal and salinity window and they settled faster in warmer conditions. However, the scyphistomae showed physiological stress in the warmest (28 °C) and saltiest (38) treatments. Asexual propagation and ephyra growth were greater at mid temperature (23 °C) and in hyposaline (24) conditions. Their ability to grow in hyposaline conditions raises the possibility that some or all reproductive stages may occur in estuaries or other brackish environments. The ongoing ocean warming and the decrease in rainfall are discussed to explore the implications in this jellyfish population dynamics.
Duration and magnitude of the winter cold period influence strobilation success in *Aurelia aurita* in southern England

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Regional warming in coastal areas is likely to bring about milder winters and may modify the bloom potential of scyphozoan polyps, which produce medusae in response to spring warming. We hypothesised that *Aurelia aurita* polyps, incubated under multiple combinations of: (i) temperature observed in this region (4°C, 7°C, 10°C); and (ii) duration representing the winter period (2, 4, 6, 8 weeks), would produce more ephyrae more rapidly when incubated at colder temperatures for longer durations following a thermal trigger. *A. aurita* strobilated under multiple combinations of temperature and duration, with optimal ephyra production at 7°C with a 6 week incubation period. Production of ephyrae was low to non-existent at all durations for polyps incubated at 10°C. This supports the pre-existing notion that *A. aurita* is well adapted to average in situ conditions but contradicts the idea that increasing numbers of medusae will be produced in warmer conditions, both in the context of abnormally warm winters as well as under future climate change and global warming. Such investigations of regional specific ontogeny highlight the need to examine each life stage and its associated thermal windows separately, alongside its environmental context.
Identification of colonial species of coronate scyphozoans

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There are 4 colonial coronates: Nausithoe punctata; N. racemosa; Linuche unguiculata; and Stephanoscyphistoma allmani. Our goal was to verify differences in polyps identified as 'Linuche unguiculata'. We studied animals from: Atlantic (Brazil and Cuba); and Pacific (Indonesia, South China Sea, Japan, Papua New Guinea, and Mariana islands); and Hagenbeck zoo aquarium. We observed type of ramification; tube diameter; number of external rings; presence/absence of internal cusps and shape. No differences were found between the number of rings and diameter of the tubes. Three colony shapes (stolonal; cauliflower; and verticil), and three patterns of internal cusps (absent; cup-shaped with regular projections; and with irregular projections) were found. We concluded that the species found in Cuba and Brazil comprise a single taxonomic entity, which should be named Linuche unguiculata. The samples from the Pacific, comprise 3 species: Linuche sp. (with stolonal colony and internal cusps similar to the Atlantic species); Nausithoe racemosa (with a cauliflower colony and absence of cusps); and Stephanoscyphistoma allmani (with verticil colony and cusps with irregular projections). Further studies based on life cycle and molecular approaches will provide additional data to unravel the identities of the Pacific forms and, eventually, correlate them with already described species.
A needle in a haystack: An integrated approach to identifying the fundamental niche of the Irukandji polyp

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The Irukandji jellyfish, Carukia barnesi, is common to the tropical waters of North Eastern Australia. Due to its painful and potentially fatal sting, the seasonal presence of this marine stinger is estimated to cost greater than 15 million a year in medical expenses. Although it’s the medusa stage that is of direct threat to humans, the polyp stage drives seasonal periodicity and medusa abundance. Due to factors such as their small size and cryptic nature, which make faunal surveys near impossible, the current knowledge surrounding the ecology of the Carukia barnesi polyp is inadequate. Unsurprisingly, the polyps of C. barnesi have never been found in situ, and laboratory-based cultures form the foundation of all research on these subjects. To understand the potential distribution of C. barnesi polyps we exposed individual polyps to an 80 combination matrix of salinity (16-14‰) and temperature (11-34°C), and measured their metabolic rates. By exploiting the link between physiological performance and metabolic rate, a mechanistic species distribution model was generated and used to theorize in situ ecological scope. It is near impossible to manage the medusa without the knowledge of the polyp ecology/habitat, thus, identifying the potential niche for Carukia is invaluable.
The genomic and transcriptomic basis of behavior in a cnidarian-dinoflagellate symbiosis: *Mastigias* and *Cladocopium* of Palau

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Swimming behavior is an important attribute influencing the dynamics of jellyfish aggregations. However, the diversity and variation of behaviors between locations and species is poorly known. A classical example is mass migration by *Mastigias papua* in oceanic and isolated marine lake populations, e.g. Palau. *Mastigias* migrations can be diurnal or semidiurnal and horizontal or vertical, and can differ among populations, size classes, and individuals. These migrations are thought to be adaptations to sun exposure (neither too much nor too little) and Nitrogen uptake, as well as predator avoidance; migrations likely also influence rates of prey capture. Because this swimming behavior engages the zooxanthellae & jellyfish in a series of trade-offs, it can be hypothesized that the zooxanthellae are influencing jellyfish behavior. We set out to test this hypothesis by comparative analyses of instantaneous swimming directional data of zooxanthellate and azooxanthellate *Mastigias* occurring at the same time within a single lake. Data primarily supported a directional migration in zooxanthellate *Mastigias* but not in azooxanthellate *Mastigias*; the latter were oriented more randomly. To better understand the possible interactions between the medusae and zooxanthellae I will incorporate comparative genetic and transcriptomic analyses that can implicate the mechanistic components underlying this symbiotic association.
Vertical and spatial distribution of different life stages of *Pelagia noctiluca* ephyrae in the Western Mediterranean Sea

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Despite being the most abundant jellyfish species in the Mediterranean Sea, little is known about the early life of *P. noctiluca*. Herein, we described four stages of ephyrae based on their morphological characteristics and their size on field capture samples. To determine the stage distribution of ephyrae in the western Mediterranean Sea, we computed a model using biological and environmental data of 39 plankton samples collected in 2014-16 around the Balearic archipelago. Further, the vertical distribution of the ephyrae was evaluated with 8 stratified plankton tows from 0 to 100 m deep over 48 hours, pointing that *P. noctiluca* ephyrae predominate in the upper strata of the water column both, during the day and night. This work presents useful information on the biology and ecology of ephyrae of *P. noctiluca*. 
Physiological and enzymatic respiration in *Aurelia aurita* and *Pelagia noctiluca*

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Improving understanding of the relationship between respiration and the activity of the electron transport system (ETS) in marine organisms facilitates assessment of respiration in marine ecosystems. Here, we present our progress in investigating this relationship in jellyfish. Some scyphozoan jellyfish display complex and versatile life cycles during which they transition from sessile to planktonic life stages. We investigated physiological respiration (R) and potential respiration (Φ), derived from analysis of the ETS activity, in polyps (sessile stage), ephyra (larvae stage) and medusa (adult stage) of *Aurelia aurita*. The objective was to observe how the metabolism and biochemistry of this metamorphosing organism compared with *Pelagia noctiluca* when the polyp stage was absent. Measuring ETS activity or its equivalent, Φ, promises rapid and synoptic assessment of R in fragile jellyfish. The R-Φ relationship should provide a tool to address the impact of starvation or temperature stressors on the metabolism. Using it could shed insight on possible metabolic mechanisms behind jellyfish survival. We find that variability in the R-Φ relationship is associated with organism size, physiological state, nutritional state, and temperature. Respiration is the more sensitive variable and Φ, because it is constitutive, the more conservative.
Implications of *Pyrosoma atlanticum* grazing on phytoplankton standing stocks in the Northern California Current

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The distribution of *Pyrosoma atlanticum*, a pelagic colonial tunicate historically from tropical-temperate waters, has expanded into the Northern California Current (NCC) following the occurrence of the ‘warm blob’ anomaly in 2014 and a strong El Niño in 2016. Given the high densities of *P. atlanticum* colonies observed in the NCC in recent years it is feasible that the species could have a significant negative effect on the phytoplankton standing stock in the Northeastern Pacific Ocean. During three cruises in 2018, we measured the grazing rates of *P. atlanticum* colonies off the coast of Oregon and estimated their grazing impact on the local phytoplankton standing stock. We also measured densities and size distributions of colonies in an effort to understand their population dynamics. We observed a doubling in the median size of *P. atlanticum* colonies between February-March and May, although the pyrosomes were more abundant, on average, in February-March than in May. By September there was a marked decrease in both colony numbers and size. Despite high individual colony ingestion rates, the overall grazing impact of *P. atlanticum* remained low, < 2 % of the phytoplankton standing stock in all months, possibly due to high levels of phytoplankton in the NCC.
Defining trophic interactions between *Pelagia noctiluca* and plankton in the Gulf of Naples (Tyrrhenian Sea, Central Mediterranean)

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Since the beginning of 2019, outbreaks of the scyphomedusa *Pelagia noctiluca* (Forsskål, 1775) have occurred in several areas of the western sector of the Mediterranean Sea (mainly France and Italy). The effects of these outbreaks on the pelagic food web are still unknown because the diet of this species is not defined in the different systems where such events took place. In the Gulf of Naples (central Tyrrhenian Sea), where outbreaks of *P. noctiluca* have been recorded since 1909, a description of the diet of scyphomedusae is lacking. To define the dietary composition of *P. noctiluca* in the Gulf of Naples, we used fatty acids as trophic biomarkers, which were determined in the scyphomedusae and their potential prey (phytoplankton, mesozooplankton and gelatinous macrozooplankton). We present here the preliminary results of analyses, which show the variation of fatty acids of *P. noctiluca* and its potential prey at a monthly time scale. Based on these data, we build up a first-order-approximation planktonic food web in the Gulf of Naples. These preliminary data are crucial to define the functioning of a food web which sustains a relevant local fishery activity.
Influence of jelly-falls and aquaculture organic discharges on benthic ecosystem processes

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Jellyfish blooms have increased in magnitude in several locations around the world, including in Norwegian fjords. While the factors that promote jellyfish blooms are often investigated, the effects from the sinking and accumulation of dead jellyfish (jelly-falls) at the seafloor are still unclear. Norwegian fjords are also impacted by organic loading from aquaculture. Examining the combined impact of organic loading from aquaculture operations and jelly-falls is thus important in order to elucidate the effects caused by increasing blooms and aquaculture activities in Norwegian fjords. Here, we will present data from a series of ex situ benthic incubation experiments that examined the role of aquaculture organic discharges and jellyfish carcasses on sediment community oxygen consumption, and C-processing by benthic meiofaunal and macrofaunal communities. Our results suggest that the addition of jellyfish detritus to the seafloor and organic loading from aquaculture rapidly altered benthic biogeochemical cycling, and substantially modified C-flow through benthic communities to a greater extent than when the sediments were impacted by only organic matter settling from overlying fish cages. If our results are representative for other areas, they suggest that the combined effect of aquaculture activities and jellyfish blooms may have cascading effects for benthic ecosystem functions and services.
Prevalence, abundance and intensity of infection of a new species of parasitic sea anemone from *Chrysaora kynthia* (Cnidaria: Scyphozoa)

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Scyphozoans have diverse symbiotic associations, including mutualism, commensalism and parasitism. Here we identify and report a new association between a juvenile parasitic sea anemone and *Chrysaora kynthia* from Australia. Twenty-five adult medusae were collected from the Gold Coast Seaway, Queensland and transferred to kreisels at the Griffith Sea Jellies Research Laboratory where they were monitored. Sea anemones collected from *C. kynthia* were analysed and compared with congeners. The anemone appears to be a new species of the genus *Peachia*. This is the first Australian report of *Peachia* infecting a *Chrysaora* species. The prevalence of infection was 84%, and the mean intensity of infection was 4.5 ±0.6. The parasitic anemones appeared to castrate the medusae and ulcerate their bells. Given the very damaging effects of the anemones on the jellyfish and that adult *Peachia* are benthic, we propose this ecological association to be extreme parasitism and hypothesise that the *Peachia* kill their host medusae to facilitate transfer to the benthos. Studies that monitor the anemones until they kill the host medusae and settle on a sandy substrate to develop into adults, however, are needed to confirm their role as extreme parasites.
Jellyfish-Fish interactions in changing oceans

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Jellyfish ecology has been an object of research for the past decades, but their interactions with fish in pelagic food webs still hasn’t been examined in detail. Even though overfishing, next to climate change and eutrophication, is one of the major issues discussed in the field, to explain recent increases in jellyfish biomasses and blooming events. Concerns are rising about the impact of these blooms on pelagic ecosystems and food webs. Therefore, there is an urgent need to better understand which role jellyfish play in pelagic food webs and how they interact with fish. This study will reveal jellyfish-fish interactions by using the Baltic Sea as an example for an anthropologically highly impacted ecosystem. The specific objective of this study is to understand the trophic position of both juvenile fish and ephyra larvae of jellyfish in spring time when both overlap in occurrence. By using a combination of fatty acid and stable isotope markers from a variety of trophic levels, we aim to provide a unique inside in trophic niches of jellyfish and further discuss the relevance of potential niche overlaps with fish species.
Identification of pelagic and demersal fish predators on gelatinous zooplankton in the Northeast Pacific Ocean

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Pelagic coelenterates (Cnidaria and Ctenophora) and urochordates (salps and appendicularians) have been considered important consumers or predators in marine food webs for many years but have only recently have they been recognized as being important prey for many marine species. We summarize data obtained from > 100 Northeast Pacific fish predators based on extensive food habits analysis (~500,000 stomachs examined) from broad-scale surveys of pelagic and demersal fishes ranging from the Bering Sea to Southern California. We identified several hitherto unknown predators of jellyfish and examined factors (e.g., year, geographic area) related to predation on jellyfish. Dominant pelagic consumers of coelenterates include dogfish, rockfish, hake, medusafish, and saury and consumers of thaliacians included salmon, walleye pollock, and sablefish. We also show that the occurrence of coelenterate prey is generally much higher in stomachs of several fish species examined fresh at sea compared with that found in stomachs of the same species examined in the laboratory following preservation. Differences were less pronounced with the more durable salp prey. We suggest that many existing estimates of predation on readily digested gelatinous prey may underestimate the true predation rate and their importance in marine food webs.
Cnidase – Acraspeda: a database on medusozoan cnidome

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Cnidaria is a highly conspicuous metazoan phylum in terms of autapomorphy: the cnida. Such largest animal organelle is fully represented in all extant species, as part of the main body forms (polyp, medusa) and their different organization (solitary, colonial, hard or soft exoskeletons animals). In general, it is used for defense, prey capture, and adhesion to substrates. Several proposals/discussions were made in terms of their morphological differences and general biology (e.g., life cycles and toxins) but without a macroevolutionary framework. Here we propose the establishment of a web-based database – Cnidase Acraspeda – , as a morphological repository based on literature of almost 300 species (115 species presented some level of information) to be freely accessible. Taking into account this database, species diversity, and main morphological/ecological/life cycle traits, we generated a phylogenetic comparative analysis based on cnidae, addressing hypotheses about their evolution and potential impact on the diversity of Acraspeda.
Cnidome throughout the life cycle of scyphozoan species (Cnidaria, Scyphozoa)

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The cnidome is widely used on cnidarians systematics studies. However, there is only a few studies describing the composition of nematocysts in different stages of scyphomedusae life cycle. We studied the nematocyst types of three life cycle stages (polyp, ephyrae and medusae) of three scyphozoan species from the different orders (Nausithoe aurea, Chrysaora plocamia, and Lychnorhiza lucerna). All specimens were kept in cultivation under laboratory conditions. For identification of the nematocyst types, fresh tissue squashes were made and observed under light microscopy. Preserved tissue squashes were made to perform measurements of the capsules. We used fragments of different body parts preserved in 4% formaldehyde solution in seawater and hydrated them during four days in freshwater. For scanning electronic microscopy (SEM) the samples followed standard fixation protocols. Overall, we observed two categories of nematocysts (holotrichous O-isorhizas and holotrichous a-isorhizas) for the three species studied. The heterotrichous microbasic euryteles were only observed in N. aurea; the heterotrichous microbasic rhopaloid and holotrichous A-isorhiza seen only in C. plocamia and the heterotrichous microbasic birhopaloid – type II) in L. lucerna. For the three species the holotrichous types were more abundant than the heterotrichous.
Metalloproteinases in nematocyst venom from jellyfish *Nemopilema nomurai* are responsible for inflammation

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Jellyfish envenomations result in extensive dermatological symptoms, clinically named as jellyfish dermatitis, which can seriously affect the daily activities and physical health of people. Inflammatory response accompanies the whole process of jellyfish dermatitis and the complexity of jellyfish venom components makes it difficult to treat jellyfish dermatitis symptoms effectively. Moreover, inhibiting inflammation is essential for the treatment of jellyfish stings and exploring the main components of jellyfish venom that cause inflammation is an urgent research area. In this study, the inhibitory effects of matrix metalloproteinase (MMP) inhibitors for venom-induced inflammation were explored at a cellular level. The expression of the three inflammatory factors, IL-6, TNF-\(\alpha\) and MCP-1 in two skin cell lines, human keratinocyte cells and human embryonic skin fibroblasts cells, at the cellular level, after treatment with the inhibitors of jellyfish *Nemopilema nomurai* nematocyst venom, were determined. The results showed that inhibitors of MMP can significantly reduce the toxic effects of jellyfish *Nemopilema nomurai* nematocyst venom to skin cells. The expression levels of the three inflammatory factors IL-6, MCP-1 and TNF-\(\alpha\) in the cells were also significantly decreased, indicating that MMPs in jellyfish venom are probably vital factors leading to jellyfish dermatitis. This study is beneficial in the prevention and treatment of jellyfish stings.
Venom proteome of three blooming jellyfishes *Chrysaora caliparea, Cyanea nozakii and Lychnorhiza malayensis* (Cnidaria: Scyphozoa) from the coastal waters of India

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On triggering, nematocysts of jellyfish release a tubule that contains highly venomous compounds made of protein, polypeptides and enzymes. We have characterized the proteome of crude venom extract from three blooming jellyfish along the west coast of India, *Chrysaora caliparea, Cyanea nozakii* and *Lychnorhiza malayensis* using a Quadrupole-Time of Flight (Q/TOF) mass spectrometer analysis. Collectively 50 proteins were identified from these three species. The proteome of jellyfish venom contains pore-forming toxins, metalloproteinases, signaling proteins, transcription factors, antioxidant enzymes, photoproteins, and neuropeptides. The most abundant toxin was identified from *Chrysaora caliparea* and *Lychnorhiza malayensis* is pore-forming toxins and metalloproteinases, which possess haemolytic activities. Protective antioxidant enzyme Peroxiredoxin was identified more in *Cyanea nozakii*. Metalloproteinase from the *C. caliparea* shows similarity with the venom of pit viper (*Bothrops pauloensis*), while that of *L. malayensis* was similar to the venom of snakes *Bothrops insularis* and *Bothrops asper*. Kininogen-1 is a secreted protein, it identified for the first time from the jellyfish *L. malayensis*. Our study characterized the proteome map of crude venom extract from *L. malayensis* and *C. caliparea* for the first time and also identified more proteins from *C. nozakii* and the venom profile is compared with published information elsewhere.
Studies on abundance of jellyfish along the coast of Greater Accra Region of Ghana

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The study was conducted in three landing villages along the coast of Greater Accra Region of Ghana, namely; Ada, Bortianor and La from November 2018 to April 2019. The purpose of the study was to assess the abundance of jellyfish. Data was obtained primarily from local fishermen who deployed beach seine net. 2676 individuals representing four different families of jellyfish were encountered after the study with Ada having 988, Bortianor 377 and La 1311 of the total number encountered. A total of four jellyfish families encountered were; Catostylidae (35%), Chirodropidae (31), Pelagiidae (4%) and Rhizostomatidae (30%). 352228 individuals of fish belonging to thirteen fish families were encountered together with the jellyfish families during the study. They are; Carangidae, Cynoglossidae, Dasyatidae, Haemulidae, Lutjanidae, Sepiidae, Sparidae, Sciaenidae, Sphyraenidae Stromateidae, Trichiuridae, Portunidae and Penaeidae. Chirodropidae was most abundant in La, however, Pelagiidae, Rhizostomatidae and Catostylidae reduced in abundance at Ada and Bortianor respectively. Physico-chemical parameters in the site where fishing was carried out were collected. A Canonical Corresponding Analysis (CCA) was used to identify which of the principal water quality parameter influenced abundance of both jellyfish and fish. Five water quality parameters (DO, Conductivity, TDS, Phosphate and Chlorophyll-a) out of the eleven principal components were identified to contribute significantly (BEST, Rho= 0.852, P< 0.01) to biological variations observed.
Modelling of the effect of breakwaters on jellyfish distribution: the *Carybdea marsupialis* example

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*Carybdea marsupialis* is a cubozoan endemic to the Mediterranean Sea that inhabits shallow waters. It is usually observed in low densities but over recent decades it has been detected massively in some Italian (mainly in the Adriatic Sea), Tunisian and Spanish coastal zones. These high abundances represent a beach management challenge because although the sting of *C. marsupialis* is not fatal, it is painful and even severe systemic effects have been described in sensitive patients. In the framework of the LIFE CUBOMED project, we modelled for July 2015 the dispersal of *Carybdea* juveniles in Almadrava Beach (NW Mediterranean) where densities up to 2 adult individuals/m² were recorded since 2008 in the same area where three perpendicular breakwaters were built in 2005. We used the numerical model TRIMODENA (finite-element model) and its routines MAREAS and ECADIS, which allowed us to calculate the currents and sea level variations. Current patterns obtained from TRIMODENA where subsequently used under SOFT (*Sediment, Oil spill and Fish Tracking model*), a Lagrangian particle dispersion model. Results indicated that one of the breakwaters could act as a plankton trap, creating sticky waters around it and increasing the chance of a plankton particle to remain in a certain area.
Ocean current modelling: The importance of ocean currents for range expansion of invasive jellyfish and comb jelly species

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Invasive species are of increasing concern due to their impacts on biodiversity and food web functioning. The American comb jelly \textit{Mnemiopsis leidyi} has a >35 year invasion history. We investigate its spread dynamics throughout western Eurasia by use of geo-referenced observations, hydrodynamic modelling and molecular analysis and reveal a relationship between time of colonisation/recolonization and ocean connectivity. Recolonization from hot spot areas can be extreme with more than 1200 km per year aided through connectivity via ocean currents. As different sub-populations are present in western Eurasia, highly inter-connected areas may become important for potential hybridization events, with yet unknown invasion consequences. We argue that current connectivity patterns do not only play an important role in spread of marine invasive species but also for genetic admixture and should be considered for ballast water regulations.
Mapping the global distribution of floating Hydrozoans *Velella* and *Porpita*

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Floating open-ocean communities are collectively termed the “neuston” (sometimes also “pleuston”) and two important neustonic species are the hydrozoans *Porpita* spp. (aka blue buttons) and *Velella* spp. (aka by-the-wind sailors). These animals can be sparsely concentrations over hundreds of miles or compacted so thickly they completely blanket the ocean’s surface. *Velella* and *Porpita* are foundational neustonic organisms, serving as prey for crabs, snails, barnacles, fish, and other surface life. Here we use historical observations in combination with new citizen science data to create global maps for the distribution of *Velella* and *Porpita*. We discuss the major abiotic factors that influence the overall distribution of these two genera, as well as our current efforts to build temporal predictive models for when they will occur on regional scales. Finally, we highlight current threats to these and other neustonic species, and the role the neuston may play in the open ocean environment.
How to better calculate physiological respiration in jellyfish from enzymatic assays and enzyme kinetics

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Because O₂ consumption (R), in jellyfish results from respiratory electron transfer system (ETS) activity and its controlling enzyme kinetics, it can, theoretically, be calculated from these measurements. We are investigating O₂ consuming algorithms, based on ETS kinetics that could lead to more accurate calculations of respiration than current R/ETS based calculations. Our hypothesis is that ETS activity, in vivo, at constant temperature, when coupled to oxidative phosphorylation, is regulated both by the supply of pyridine nucleotides and by the demand for adenosine triphosphate (ATP). Cells sense this demand by the availability of adenosine diphosphate (ADP). ADP, in the mitochondrial matrix, regulates the ATP production when the voltage across the inner mitochondrial membrane is greater than 225 mv. With decreasing voltage, Complexes 1, 3, and 5 in the ETS are activated and R is stimulated. Complex 1 uses pyridine nucleotides (PN) from the Krebs and other metabolic cycles to sustain ETS redox reactions culminating in R. During nutrient sufficiency, PN abundance increases ETS electron flux and hence increases R. During nutrient limitation, PN paucity reduces the flux, decreasing R. Here, we explore the way the kinetics of these two control mechanisms can be used to model jellyfish respiration.
Potential of MALDI−TOF MS-based proteomic fingerprinting for species identification of gelatinous zooplankton

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Accurate species identification is a prerequisite for ecological studies on gelatinous zooplankton. However, morphological identification can be challenging, for example in small hydromedusae and juvenile scyphomedusae (ephyrae), and DNA-based identification methods are often time-consuming and cost-intensive. Proteomic fingerprinting is a well-established tool for the identification of microbial species and was recently also successfully used for species discrimination of metazoan taxa like fish and arthropods. In the present pilot study on gelatinous zooplankton species, we applied matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS) on ethanol preserved samples of North Sea medusae (Scyphozoa and Hydrozoa) for proteomic measurement. Our analyses confirmed that jellyfish species can successfully be discriminated based on species-specific proteome profiles. Within the same scyphozoan species, different developmental stages (ephyrae and medusae) clustered together as well as field samples from different locations (North Sea and Baltic Sea). Moreover, freshly preserved (<6 months) and longtime stored samples of the same species clustered together. These results verify that gelatinous tissues are suitable for species discrimination by MALDI-TOF MS. In conclusion, proteomic fingerprinting could provide a promising alternative or supplementary tool for a rapid and cost-effective species identification of gelatinous zooplankton organisms.
Predation or photosynthesis? Nutritional variability of *Mastigias papua* using stable isotopes and fatty acids

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Whereas jellyfishes are well recognized as pelagic predators, they are less often considered as mixotrophic organisms. However, a number of jellyfish species host photosymbiotic zooxanthellae. Their nutrition is therefore derived from both predation and zooxanthellae’s photosynthesis. In marine ecosystems, the abundance of prey, nutrients and light vary. This is likely to induce variation in zooxanthellate jellyfishes’ nutrition. How zooxanthellate jellyfishes cope with such variations is little understood. With this study, we attempt to characterize the nutritional variability of the zooxanthellate jellyfish *Mastigias papua* from Palau (Micronesia) using stable isotopes and fatty acids trophic markers. The marine lakes and lagoon of Palau exhibit a range of different environmental conditions that are likely to influence *Mastigias papua* nutrition in contrasting ways. Our results suggest that *Mastigias papua* nutrition can display a wide variability from mostly autotrophic to completely heterotrophic. We then discuss the environmental factors that might underpin these variations. Beyond immediate ecological implications, this study also demonstrates that stable isotopes and fatty acids are valuable tools for the understanding of the nutrition of zooxanthellate jellyfishes in the field.
Observations on population connectivity amongst holopelagic and mesopelagic Scyphozoa around Africa

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Given the relatively homogeneous nature of the mesopelagic it can be hypothesised that connectivity between populations of meroplanktonic coronate jellyfish around Africa would be high – especially given the iteroparous nature of reproduction of species such as those of *Atolla*. It might also be expected that connectivity between populations of holoplanktonic but epipelagic Discomedusae may also be relatively high, especially by comparison with meroplanktonic relations. Here we investigate the genetic structure of *Atolla wyvillei* and *Pelagia noctiluca* from around Africa, using the mtDNA marker cytochrome c oxidase subunit I (COI), in order to understand the role of depth on population connectivity.
Hydro-acoustic discrimination, and biomass estimation, of jellyfish along the Namibian coast

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The size of the jellyfish populations off Namibia is thought to have increased significantly since the end of the 1960s, likely as a result of overfishing and possibly climate change. Multi-frequency hydroacoustic tools have been developed to survey for jellyfish, and these were applied during 2003 in order to estimate the biomass of jellyfish in the northern Benguela upwelling ecosystem. The results of that survey suggested that there were more jellyfish off Namibia then, than commercial fish of all species combined. Unfortunately, this tool has not been routinely used to assess jellyfish biomass subsequently. Following dedicated surveys aboard the Dr Fridtjof Nansen in 2017 and 2019, I reassess the biomass of jellyfish in the region using multi-frequency hydroacoustics tools I refine here. And compare the findings to those of 2003. Acoustic survey data will be processed using Echoview and Large Scale Survey System (LSSS). All data analysis will be conducted using R Version 3.2.2 software package.
Using unmanned aerial vehicles to measure jellyfish aggregations

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Unmanned aerial vehicles (UAVs, or drones) are becoming increasingly common as tools to perform high-resolution but broad-scale measurements of habitats and populations simultaneously. In this study, we tested the application of UAVs to aerial surveys of jellyfish and their suitability for measuring and monitoring aggregations. We paired net hauls with linear image transects taken by a UAV to measure five Aurelia spp. aggregations over the course of 1 day in Pruth Bay, British Columbia, Canada. Georeferenced image transects were processed to determine aggregation areal extent and estimate percent cover of jellyfish. The percent cover estimates and net haul density data were highly comparable for all aggregations. Using combined UAV-derived surface area estimates and net haul biomass estimates, we calculated that jellyfish aggregation size ranged from 65-117 tons wet weight biomass. We discuss the potential for additional UAV-based measurements including jellyfish abundance and individual size. The study demonstrates the potential of UAVs as powerful tools for characterizing and researching jellyfish aggregations in situ.
The Arctic Jellies (ARJEL) project: Investigating the impact of gelatinous zooplankton communities on changing Arctic ecosystems

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Gelatinous zooplankton are known to be major drivers of ecosystem changes. Increases in jelly biomass, referred to as “jellification”, have been observed in several marine ecosystems, causing, amongst others, the collapse of major fisheries. For the Arctic region, abundance data on jellies are virtually non-existent, impeding our ability to detect changes of a similar magnitude. To better understand the role of jellies in the Arctic seas, the Helmholtz Young Investigator project ARJEL (2019-2025), will combine the most recent technologies in optics, acoustics, and environmental DNA analyses. Integrative field surveys will allow us to link distributional patterns of jellies to sea-ice and oceanographic features. Furthermore, we will apply species distribution models to a broader set of archived data to understand observed species patterns and to predict changes under future scenarios. The role of jellies in the Arctic food web, their importance for higher trophic levels and their link to the sea-ice trophic pathway will be elucidated with metabarcoding and biomarker studies. Physiological and transcriptomic studies serve to predict range expansions, and consequences of expansion will be predicted based on food web models. An overview of the goals and methods planned will be given with scope for collaborations.
Patterns of morphological development in Scyphozoa ephyrae (Cnidaria, Medusozoa)

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Describing morphogenesis of feeding structures during ephyrae differentiation can reveal functional and evolutionary information that increase the knowledge about the species trophic roles and how the jellyfish respond to blooms stressors. To characterize the bauplan in Scyphozoa evolution, we studied bell and oral arms development. We seek the existence of developmental patterns, and thus observed ephyrae growth in ten scyphomedusae species. Newly released ephyrae were cultivated until young medusa morphology. To propose developmental models, we used growth curves based on measurements of bell and oral arms. We found bell patterns that support the family Ulmaridae as a sister group of the Rhizostomeae (Ulmaridae has similar emergence velar lappets to the Rhizostomeae and different to the others Semaeostomeae), and, within rhizostomes, the split of Daktyliophorae and Kolpophorae (the character “serrated lappet” is present only in Daktyliophorae). Moreover, we propose a specific oral arms definition using morphologic and functional characteristics, which considers the handling capacity of the food. Estimating developmental timing of these structures improves the understanding of possible early developmental transitions in feeding strategies and on jellyfish-fluid interactions. This approach, therefore, may reveal responses to environment changes as caused by stressors that hypothetically induces blooms.
The reliability of morphological features to distinguish species within the upside-down jellyfish cryptic complex (Rhizostomeae: Cassiopeidae: Cassiopea)

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So far, it has not been possible to establish species boundaries among members of the family Cassiopeidae, which could reflect the lack of taxonomic studies directed to this group. Solid taxonomic bases are essential for the discovery and effective control of invasive species, and they are equally crucial for understanding the biological processes that derive from the study of model species. In order to establish taxonomic bases for this group of jellyfishes, which are hypothesized to be invaders in several places, and which serve as model species for biological research, we set out to conduct a taxonomic revision of the family. Specimens housed in museums, cultivated in laboratories and aquariums and newly collected were inspected. On one hand, some characters derived from the observation of the mouth-arms, subgenital pits, and gastrovascular canals were found to be useful for defining some species, allowing us to describe new species from the Indo-Pacific region. However, morphology was not always reliable to distinguish and establish limits between certain species, thus complementary sources of evidence should be used to strengthen current and establish new species hypotheses. Other taxonomic actions that followed our revision include redescriptions and the consideration of a nomen dubium.
Morphological review of the genus *Nausithoe* (Nausithoideae, Coronatae, Scyphozoa, Cnidaria) and description of new species from South West Atlantic

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The order Coronatae is generally known as being composed of deep-sea medusae species, although part of the diversity also occurs in shallow waters. Some species of the genus *Nausithoe Kölliker*, 1853 (Nausithoidae, Coronatae) were described 100 years ago and have never been found again. As a result, their morphological features cannot be well-reviewed due to the near absence of original vouchers and other specimens for comparative inspection. As with most scyphozoans, a majority of the 22 presently accepted *Nausithoe* species have a metagenetic life cycle, involving the alternation of polyp and medusa generations. Similarity of the polyps within the genus makes it necessary to study the medusa stage for taxonomy. We explored the diversity of the genus, questioning the feasibility of using some characters of the medusa stage to identify species and filling gaps concerning the diversity and distribution of the genus. Morphological features were observed on preserved and live *Nausithoe* specimens (polyp and medusae), comparing these data with the original descriptions. With our data we were able to validate twelve species, bringing new information for some of them and describing a new species for the Brazilian coast.
History of female gonads and oogenesis in *Chiropsalmus quadrumanus* (Cubozoa Cnidarla)

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The box-jellyfish *Chiropsalmus quadrumanus* (F. Müller, 1859) (Chirodropida, Chiropsalmidae) is common in the warm waters from southern Brazil to North Carolina, USA. The cubic umbrella can reach 10 cm in height and 14 cm in width. Although it is assumed that external fertilization is a characteristic of Chirodropida, life history of *C. quadrumanus* is not well known, since its reproductive behavior has never been described and the polyp has never been found in nature. As a result, there is no information on the sexual reproduction of this species to support the external fertilization hypothesis. Here we analyzed eleven females collected during the dry season on São Sebastião Channel (São Paulo, Brazil) in different years. The histological samples were fixed in formaldehyde 4% and processed for techniques in histo resin. We describe the gonadal organization in females and oocyte development in specimens with different stages of maturity. *Chiropsalmus quadrumanus* has eight hemi-gonads in four pairs, situated at the radial canals. Mature female gonads contain mature and immature oocytes. Mature oocytes are 129 ± 15.4 μm in diameter in average. Four different stages of oocyte development were identified, and no specimen collected was found spawning.
What makes blue jellyfish, blue? Searching for homologs of the new class of animal pigments from *Rhizostoma pulmo*

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Colouration in Cnidaria results mostly from carotenoids, tetrapyrroles, melanins and the green fluorescent protein (GFP) family. A new class of animal pigments, a blue protein with Frizzled and Kringle domains, was described from the jellyfish *Rhizostoma pulmo* (named *rpulFKz1*). Other rhizostomes, such as *Cassiopea xamachana*, also possess blue pigmentation, whereas others such as *Nemopilema nomurai* are usually red-brown. Our goal was to search for homologs of *rpulFKz1* in cnidarians, to investigate how pigmentation in jellyfish might have evolved. We used a BLAST-based approach to search for homologs in the 25 cnidarian genomes available in GenBank. Clear homologs were found in rhizostomes, however proteins containing both Frizzled and Kringle domains were also found in hexacorallian anthozoans (mostly scleractinians). To date, scleractinian colour has been attributed to GFP-like proteins, so it is possible that these Frizzled/Kringle proteins have other functions in corals. These results provide hints about the potential role of these protein domains across cnidarians, which can give us further insight into colour variation and expression in jellyfish.
Barcoding West African jellyfish – preliminary insights into species diversity off the west coast of Africa

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Our understanding of scyphozoan jellyfish diversity around Africa is scant and there are few recent records, let alone descriptions. This leads to an underestimation of diversity and hampers efforts to document distributions. Here we present some preliminary data on the species collected along the West Coast of Africa during the surveys of the Dr Fridtjof Nansen during 2017. These observations are based on the barcoding of COI genes, and are supplemented in some cases with morphological descriptions.
The symbiotic case study of zooxanthellae living inside the jellyfish *Cotylorhiza tuberculata*

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The symbiotic association between the zooxanthellae *Symbiodinium* sp. and its host jellyfish, the rhizostome scyphozoan *Cotylorhiza tuberculata* was studied. Measurements were carried out in two different sections of the medusa body to investigate distribution of the alga *in hospite*: oral arms (OA) and umbrella (UM). Medusa carbon and nitrogen composition were higher in the OA section than UM (4.43 ± 0.3 and 3.7 ± 0.26 respectively). No significant differences were found in the chlorophyll *a* content among the two sections. However, zooxanthellae density was higher in OA than UM tissue. A total of 13 different pigments was revealed by the High Performance Liquid Chromatography (HPLC) method, the most representative pigments were chlorophyll c₂ peridin and diadinoxanthin, typical pigments of dinoflagellates. Cell diameter was significantly higher *in hospite* (8.71 ± 0.94 μm) than *in culture* (6.78 ± 0.85 μm), whose growth rate value was 0.285 (± 0.09) d⁻¹. Cultures of *Symbiodinium* sp. observed by light microscopy, cytograms, and SEM micrographs, showed three subpopulations of autotrophic cells: a bigger and a smaller coccoid stage, and a motile flagellate stage. The presence of zooxanthellae living in symbiosis with *C. tuberculata* may be a reason added to explain the population success of this jellyfish.
The fatty acid profile of *Aurelia aurita*: significant differences between the bell and gonad tissues

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Classically, jellyfish have been regarded as a trophic ‘dead-end’ due to their low energy density. However, it is now known that a great diversity of species feed on jellyfish including commercially important fish species such as mackerel and herring. It has also been observed that some species selectively consume the gonads of jellyfish. However, it remains uncertain why such predators selectively target these tissues with such low energy densities. To investigate this, *Aurelia aurita* samples were hand collected off the south west coast of Cork, Ireland. Fatty acid analyses were carried out on bell and gonad tissues to examine whether there was a difference between the tissues and to ascertain whether this species offers a dietary value that goes beyond a simple energetic gain. It was found that there was a six-fold difference in concentration of fatty acids between the bell and gonad tissues (median = 23.60 µg/ml and median = 134.75 µg/ml respectively). The fatty acids which were most abundant were EPA (26.40%), palmitic acid (C16:0; 13.16%), stearic acid (C18:0; 12.21%) and DHA (11.76%). The large proportions of ‘high quality’ polyunsaturated fatty acids such as EPA and DHA in *Aurelia aurita* indicate that while predators may not obtain a large energy benefit from the ingestion of these jellyfish, they are getting a nutritional value beyond energetic gain.
The relative importance of gelatinous to crustacean zooplankton determined using six abundance and biomass methodologies

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Few plankton studies fully quantify the abundance and biomass of both the gelatinous and the crustacean zooplankton factions. Yet understanding the relative abundance and biomass of these two groups can help resolve their respective importance in marine food webs. To address this question, 15 plankton samples were collected using a 0.4 m plankton net with a 200 µm mesh, from the southwest coast of Ireland. All gelatinous zooplankton (n = 5,234) were separated out from six of these 15 samples using a stereomicroscope and fine pointed forceps. The separation of the two groups allowed for five different biomass determination methods to be compared. In total. Over 12,000 gelatinous and 80,000 non-gelatinous zooplankton were enumerated and identified to the lowest taxonomic level possible, representing a ratio of 6:1 crustaceans to jellyfish. This comparison shows that jellyfish are typically less abundant than crustacean zooplankton, however they may contribute up to 43% of the dry weight of the total zooplankton community.
An unusual new jellyfish from estuaries along the south and east coasts of South Africa

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The appearance of an unknown rhizostome jellyfish has been noted periodically in estuaries along the east and south coast of South Africa over the last decade. From material collected between 2013 and 2018, it is clear, that this species differs from other rhizostomes in the region. It was initially thought to be a species of *Catostylus*, but more detailed morphological and molecular analyses have revealed some discrepancies. Specimens have an intra-circular anastomosing mesh-work that connects to the ring canal but which does not connect to the inter-radial canals, suggesting Lynchnorhizidae rather than Catostylidae. This species has 6 approximately equal (4 rounded marginal and two roughly triangular rhopalia) lappets per octant; it lacks papillae on the exumbrella surface and possesses neither clubs nor filaments in the distal portion of the oral arms. The distal frilly portion of the oral arm is approximately 1.3 x the size of the smooth portion. The cnidome includes large and small rhopaloids, and large and small oval-shaped holotrichous isorhizae. Molecular analyses of CO1 indicate that specimens form a separate clade from Catostylidae, and that there is some genetic structure between the populations from the different local estuaries. This is discussed.
World Atlas of Jellyfish: a new source of taxonomic data about cubomedusae and scyphomedusae

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The recently published book World Atlas of Jellyfish presents data for 47 species of box jellyfishes and 164 of scyphomedusae, besides general chapters on morphology, fossil record, nematocysts, life cycle, photography, jellyfish use as food, and so on. The book was organized to serve as an identification guide for researchers in the field, but also to general people attracted by the beauty and elegance of such amazing marine planktonic creatures. There is a general pictorial key organized based on the body shape of the animals, which have entries for almost all families, and morphological-based keys for species in the family sections. Valid species of the main groups Coronamedusae, Discomedusae, and Cubomedusae are described and illustrated based on the most updated literature available focusing on the diagnostic features.
First record of *Phyllorhiza punctata* (Cnidaria: Rhizostomae: Mastigiidae) in the Northeast Atlantic Ocean

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The Australian spotted jellyfish, *Phyllorhiza punctata*, has not been previously recorded in any Northeastern Atlantic Ocean coast. Here, we present the first record of the species in the Gulf of Cadiz. Five field surveys were performed in the Rio San Pedro tidal creek, communicated with the Bay of Cadiz, in the southwestern Atlantic coast of Spain. *P. punctata* specimens were observed and collected in August and October 2018. Ten specimens of different sizes were collected, from 9 to 180 mm umbrella diameter including metaephyrae, small, juveniles and adults. The presence of a wide range of sizes makes it possible that these medusae were released from polyps attached to solid substrata and probably are reproducing locally. Future observations are needed to show if the jellyfish can establish a stable population in this new habitat.
Inventory, bio-ecology and potential impact of the main jellyfish species off the Senegalese coast

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Jellyfish belong to the plankton family (Natural History Museum, 2015), i.e. cnidarians (Ifremer, 2005). In recent decades, unusual outbreaks of jellyfish have been observed in different parts of the world (Ifremer, 2015) with a rhythm and intensity that appears to be accelerating (Purcell, 2012). In West Africa, this phenomenon is due to upwellings, the overall decline in stocks and the lack of human consumption of these gelatinous organisms. The results of the 2015 UEMOA campaign revealed that jellyfish account for 6% of catches in Senegal (UEMOA, 2015). The project we are going to work on is an innovative one, because so far no studies or specialists concerning jellyfish on the Senegalese coast are known. It will make it possible to make an inventory of existing jellyfish in Senegal. More specifically, this study aims to (1) identify and describe jellyfish species, (2) study biology, ecology, specific composition, abundance, biomass, seasonality, spatial-temporal and bathymetric distribution, (3) environmental factors in the structuring and proliferation of jellyfish and (4) conduct psychosocial research at the local level.
A new species of box jellyfish (Cnidaria: Cubozoa: Carybdeida, *Copula*) from Western Mediterranean Sea

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A new species of cubozoan jellyfish belonging to the genus *Copula* (Cubozoa: Carybdeida; Tripedaliidae) is described from El Campello, Alicante, SE Spain. Prior to this study, the only box jellyfish species recorded in the Western Mediterranean was *Carybdea marsupialis* and the genus *Copula* just included a single valid species (*Copula sivickisi*, formerly named *Carybdea sivickisi*) reported from different temperate, tropical and subtropical localities in the Pacific, Atlantic and Indian Oceans. Based on morphology, this new species, *Copula* sp. nov., resembles *C. sivickisi* by having four adhesive pads toward the apex of the exumbrella—typical characteristic of the genus *Copula*-, but differs from the holotype in the rhopalial niche opening and the structure of velarial canals. Molecular data from regions of mitochondrial COI and 16S corroborate its specific distinction. The record of this jellyfish is an indication that the Mediterranean Sea still requires studies on planktonic organisms. Fortunately, there is no evidence of accidents related to envenomation by this species, but it is not possible to reject the occurrence of different species with some potential risk to public health.
Patterns and trends in jellyfish diversity in the Macaronesia region

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In this review, we present a pioneer snapshot of the current state of jellyfish biodiversity in the whole Macaronesia region, comprised by the Azores, Madeira, Canary Islands and Cape Verde island systems. Based on a comprehensive literature survey, historical records, richness estimation and biogeographical distribution, our search included organisms belonging to Scyphozoa, Hydrozoa (benthic species excluded) and Ctenophora. Our findings indicate that Macaronesia comprises 216 jellyfish species; 52.3% recorded in Azores, 41.2% in Canary Islands, 36.2% in Cape Verde and only 7.4% in Madeira. However, non-parametric statistical incidence estimations suggested the inventory completeness do not exceed 49%, varying within taxon. While jellyfish with a meroplanktonic life cycle are more diverse, Macaronesia stands out with the dominance (60%) of holoplanktonic species, likely related to the archipelago’s oceanography and location. Nevertheless, the comparison between the four archipelagos revealed a low similarity, even between islands belonging to the same ecoregion. However, these results might be affected by the lower and unequal sampling efforts in the different archipelagos. Finally, this study represents the first overall assessment of jellyfish biodiversity in Macaronesia, constituting a solid baseline for future surveys in the region.
New records of *Brooksia rostrata* and *Thetys vagina* (Class Thaliacea: Order Salpida) with introduction tunicate in Korean waters

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Class Thaliacea order Doliolida and Salpida increase every year in Korea, by climate change. Massive blooms of the Doliolida and Salpida cause damages of fisheries at Jeju Island. The Eastern Sea and southeastern coast of Korea, the way of warm current, Thaliacea blooms and harm damages rapidly increase every year. Two species in two genera were newly identified from Korean waters: *Brooksia rostrata* (Traustedt, 1893); *Thetys vagina* Tilesius, 1802. Including two newly reported species in this paper, 26 species 13 genera, 2 orders in the crass Thaliacea have been recorded in Korean waters.
Mnemiopsis leidyi – a successful invader in the northern Adriatic Sea

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Mnemiopsis leidyi is listed among the 100 of the World’s Worst Invasive Alien Species. By now, it inhabits almost all European marine water bodies. From the northern Adriatic Sea (NAD), it was first reported in October 2005 and disappeared from the water column soon after, to only reappear in summer 2016. Based on a two-year monitoring (2017-2018) we report, that the non-native ctenophore was present in the water column all year around and was spread across the NAD. The maximum average abundances were detected in late summer and early autumn (6 ind/m³). The population declined in November and from December to early July the ctenophores were observed only sporadically. The first reports of large aggregations in summer were from the enclosed environment of the Grado and Marano Lagoon and it was observed in the open waters only after a lag of several days. Such population dynamic is supported with M. leidyi reproductive performance (6 - 28°C): the highest egg production was at 19°C, it declined steadily with a SWT decrease until 6°C, at which the ctenophore ceased to reproduce. Therefore, we hypothesize, that the shallow lagoons with low water exchange prevent the dispersion during the period of low abundance and presents an overwintering refugia that maintain a persistent M. leidyi population in the NAD.
Biogeography and phenology of *Rhizostoma pulmo* in the Mediterranean Sea

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*Rhizostoma pulmo* is one of the largest and most abundant scyphozoans in the Mediterranean Sea. It inhabits nearshore waters and coastal lagoons and is responsible for bloom events with negative impacts on fisheries and tourism. We analyzed probably the most comprehensive data set including scientific and citizen data of the occurrence of the species in the Mediterranean and Black Seas covering the last 30 years. We depict basin scale patterns of abundance and phenology and discuss in the light of reported trends of warming and productivity. Our results show an intensification of bloom’s frequency and intensity in the last decades in the Mediterranean Sea, in concurrence with positive temperature anomalies. Also, we show that the timing of the seasonal peak has moved significantly forward over the past 10 years, inversely correlated with positive temperature anomalies. A phenological variability across the Mediterranean regions was identified: a summer or spring bloom in the Black Sea and the Aegean-Levantine sub-basin, respectively, or a presence throughout the year in the Adriatic Sea and Ionian-Central sub-basin. Based on the analysis of *R. pulmo* time series in the Mediterranean Sea, significant underlying patterns over the past decade have emerged although phenological differences are observed across sub-basins.
The growing pains that turned out to be
Chrysaora fulgida and Chrysaora agulhensis

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Two Oceans Aquarium, South Africa

Chrysaora fulgida and C. agulhensis are two of the three Chrysaora jellies endemic to the southern coast of Africa. All year round, C. fulgida is a dominant Scyphozoan jelly in the northern regions of the Benguela Current, whereas C. agulhensis are fairly cosmopolitan around the region only seasonally. The life cycle of these jellies has yet to be formally described, but they are grown and exhibited at the Two Oceans Aquarium. Establishing the life histories of these species is key to understanding their appearance, persistence and disappearance throughout the year. They are a nuisance to fisheries in the Benguela and shut down industries like Koeberg nuclear power station with their “sudden appearance”. The Benguela is considered the most productive upwelling system in the world, thus understanding upwelling and temperature shifts during culturing was key to achieving success in a species that have eluded culturing for over a decade. It has also permitted for innovative ways of keeping strobilae in stasis for up to two months, allowing the growth of these species at later, more favourable times. Our ability to grow these species not only allows the Aquarium to exhibit novel species, but also aids in understanding the jellification of the Benguela and why these species can easily persist both within and out of season.
A legacy of Max Egon Thiel: An unpublished manuscript and a review about four decades of Rhizostomeae research since 1979

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Max Egon Thiel (MET, 1898-1979) published eight volumes of extended monographs on Scyphozoa within the series BRONN’s Klassen und Ordnungen des Tierreiches. The edition started in 1936, got interrupted by World War II, and continued after 1957 until 1977. MET’s scientific legacy included over 800 typed pages of a manuscript on Rhizostomeae with tables and about 500 figures, all in German. In recent years this manuscript was digitized, reviewed and partially revised (condensed). Like the other volumes, the manuscript provides an extensive review of the entire (historic) literature on Rhizostomeae up to the 1970s. Thiel’s published monographs have kept their value as extensive references with regard to 18th and 19th century fundamental scyphozoan research, including discussions of various transient theories and scientific progress. Yet, this ninth volume of the series remained unpublished. We explored available interest of the scientific community to edit the remaining work and found strong support from several colleagues. The concept: A review article by a multi-author cooperative to reflect the progress and state in research on the Rhizostomeae during the last 40 years. Published in a peer-reviewed journal in English language it would introduce and frame MET’s revised manuscript published as a digital supplement.
Planktonic hydrozoans variability in the subtropical estuarine system of Paranaguá Bay, Brazil

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High spatial resolution samplings were performed throughout the Paranaguá Estuarine System (25.8S 48.8W) during summer 2012, 2013 and 2014 and winter 2012 and 2013. About 49,000 organisms were analyzed by taxonomical and multivariate methods. The highest abundances were recorded during summer, with a peak of > 2,300 ind.m$^{-3}$ in 2012. Estuarine winter assemblages showed lower densities (maximum average of 3 ind.m$^{-3}$ in 2013), but higher species diversity, due to the influence of the adjacent shelf; a condition evidenced by the occurrence of species commonly found at outer estuary, such as the siphonophores Nanomia bijuga and Abylopsis tetragona (Relative Abundance < 0.1%) and the hydromedusae Proboscydactila ornata, Ectopleura dumortieri and actinula larvae (RA < 1.0%). The estuarine Cnidostoma fallax (RA 52%) was the most important species in abundance and frequency, followed by the coastal species Clytia spp. (RA 18%), Obelia spp. (RA 14%) and Liriope tetraphylla (RA 6.5%). The results indicated strong environmental influences on the community structure. The spatial distribution was mainly determined by species preferences and tolerances for salinity conditions. On the other hand, the abundances were strongly related to higher water temperature and precipitation rates, associated with nutrient inputs and food supplies in the system.
A long way from home: Invasion of the Pacific Hydrozoan, *Aequorea australis*, into coastal New Jersey waters

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In the summer of 2017, 22 unknown medusae were collected from coastal New Jersey waters. Initial morphological identification placed these individuals in the genus *Aequorea*, but they did not match the known native species. Consequently, a molecular assessment was conducted. DNA was extracted and the 16S gene was evaluated through sequence analysis and compared to known specimens in GenBank. Results from the analyses yielded four genetic clones from New Jersey, all of which matched *Aequorea australis* ranging from 92-96% homology. These samples were then sequenced using CO1 primers and results identified four clones which all match *A. australis* in GenBank with a homology percentage of 91-93%. While the analysis of these sequences seems to point towards this unknown species as being *A. australis*, it cannot yet be confirmed as there is a possibility that *A. australis* is just the closest species match GenBank has available. Continuous observation of medusa in 2018 indicates that it is highly probable that this species of *Aequorea* has become a well-established invasive species in this region of New Jersey and is a new addition to the growing list of non-native cnidarians inhabiting the western Mid-Atlantic.
Monitoring of Scyphozoan jellyfish species in the adjacent waters of a power plant, Liaodong Bay, China

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In recent years, jellyfish bloom usually cause enormous ecological, economic and societal problems in Bohai Sea. During July and September, the population abundances and distributions of three scyphozoan jellyfish species Nemopilema nomurai, Cyanea nozakii and Aurelia sp.1 were examined by trawl surveys once per month, along with the investigation of the metrological conditions, water temperatures, salinities, chlorophyll a concentration and the zooplankton abundances. All the three jellyfish species showed great variations on bell diameter, population abundance and distribution character. The abundances of N. nomurai, C. nozakii, and A. sp.1 were 0-170 ind/net, 0-5 ind/net and 0-270 ind/net, respectively. The mean bell diameter of N. nomurai increased from 57.29 cm in July to 68.46 cm in September; the mean bell diameter of C. nozakii increased from 40 cm in July to 51.5 cm in September; and the mean bell diameter of A. sp.1 is about 20 cm during the survey period. During the three months, N. nomurai distributed throughout the survey area, and the number decreased since July. The number of C. nozakii increased since July. A. sp.1 distributed in the near-shore shallow water in July and August, and expanded southward into offshore deeper water in September, the number of A. sp.1 reached the maximum in August.
Rise and demise of *Gonionemus vertens* blooms

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The invasive clinging jellyfish, *Gonionemus vertens*, was first documented in 2016 from New Jersey. It is a small hydrozoan whose adult medusa stage 'clings' to sea grasses and other submerged aquatic vegetation. Since this initial siting, it has spread throughout several estuaries and now poses a serious potential threat to human safety, as its' sting frequently requires hospital care. Inherent to its life history, *G. vertens* produces adult medusa in May, but several factors seem to contribute to the cessation of bloom conditions. Specifically, top-down predation by sea nettles (*Chrysaora chesapeakei*) can control the population out-break, but thermal stress can also cause their decline. We demonstrate through laboratory experiments and field observations that the demise of *G. vertens* populations results from top-down pressure by sea nettles, water temperatures exceeding 28°C or a combination of both. Understanding the thermal decline in areas where predatory species are not present is critical for managing public awareness of this hazard. Monitoring of high human use areas for thermal minimums can reduce potential encounters with this highly venomous species.
GelAvista: Citizen Science for the monitoring of Jellyfish in Portugal

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GelAvista is a citizen science program designed to acquire data on the jellyfish occurring in Portuguese waters. The program was born from the need to acquire knowledge about gelatinous organisms, especially the most stinging, taking into account the recent theories that point to an increase in their occurrence in a context of climate change. Another objective is to obtain information on the diversity and dynamics of the populations of these organisms, on extended temporal and spatial scales, aiming at their regular monitoring and the development of predictive models of the occurrence of some species, such as Physalia physalis. Finally, the project also intends to contribute to increase ocean literacy in general and of gelatinous organisms in particular. GelAvista was created in the beginning of 2016 and collects information on the gelatinous organisms in the Portuguese mainland, as well as the Madeira and Azores archipelagos. Physalia physalis (Portuguese man-of-war) has been, together with Catostylus tagi, the most recorded and abundant species all over the Portuguese seas, especially during 2019. Data seem to indicate a strong influence of the wind regime on its occurrence in coastal zones. Work on molecular analysis of the species is also underway.
Impact of microplastics in jellyfish

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Although plastics and their effects are increasingly studied, especially on key species for humans, there is still much to know about how they affect other organisms such as medusa and siphonophores. Therefore, in the present work it is studied, for the first time, whether plastic ingestion occurs in *Aurelia aurita*, and if factors such as the concentration of microplastics or the presence of prey affect ingestion and retention time. Jellyfish were exposed to different concentrations of polyethylene microspheres, in presence and absence of prey, and it was observed, every ten minutes, if they had ingested microplastics. Results showed that microsphere ingestion only occurs in presence of prey (48h-artemia nauplii). In addition, no significant differences were found between ingestion times at different microplastic concentrations. As a result of this first experiment, we can deduce that the ingestion of microplastics in *A. aurita* occurs accidentally when they ingest their food.
Current trends in jellyfish blooms: Investigating the impact of climate change through population modeling

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There is concern that the frequency and magnitude of jellyfish blooms will increase globally as a result of anthropogenic changes. The data supporting this are limited. Two meta-analyses offered different conclusions regarding jellyfish trends: Brotz et al. (2012) suggest there have been increases in jellyfish biomass in most regions, whereas Condon et al. (2013) suggest that the perceived increases are part of a natural 20-year periodicity. We combine these datasets with mechanistic global plankton food web and jellyfish population models to further elucidate jellyfish trends and their drivers. Simulated jellyfish biomass corresponds well with observed trends reflected in the global jellyfish index ($r = 0.79$, $p < 0.001$). Further scrutiny, however, reveals that variation in this index largely reflects climate variations in the heavily observed North Atlantic region, not a global trend. The model also confirms the regional increases observed due to climate variations. Zooplankton biomass is a more influential driver of medusa biomass than temperature. Future projections identify that regions with increases in zooplankton biomass correspond to the greatest increases in medusa biomass, suggesting that warming temperatures alone may not result in increased blooms of jellyfish in the future as previously believed.
Effects of climate change on the distribution and diversity of gelatinous zooplankton in the Fram Strait (Arctic Ocean)

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Gelatinous zooplankton (GZ) are an important component of marine ecosystems. Aside from their multiple ecological roles, their diversity and distribution reflect particularly well local hydrological settings allowing for developing biotic indices to study climate mediated changes in the World's Ocean. Effects of global warming are most pronounced in the Arctic Ocean and are further accelerated by the increasing inflow of the warm Atlantic waters via the Fram Strait, called atlantification. We therefore decided to study jellyfish diversity, distribution and demography from vertically stratified samples (down to 1000 m) collected in the Fram Strait along two latitudinal transects of varying influence of Atlantic waters to better understand the effects of climate change on GZ in the Arctic. We have identified 17 taxa, with Aglantha digitale being the most abundant. By contrasting GZ data with environmental ecosystem characteristics we show that the more abundant gelatinous community is associated with the Atlantic waters, with the maximum at the core of West Spitsbergen Current and that the extent of this current shapes vertical demography of GZ. Our results indicate that the progression of atlantification will promote expansion of boreal species to the Arctic, affect GZ's reproductive success and consequently result in major biodiversity changes.
A Preview of jellyfish diversity and ecology at the Kribi coastal zone of Cameroon, South-East Atlantic

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Jellyfish research is an ongoing activity over the world with many areas being targeted. In Cameroon, these activities are at their infancy with a pioneer work started since June 2017 aiming at assessing jellyfish biodiversity at the coastal marine zone of Kribi, where they are considered by-catch product of the fishery sector. The first part of the study consisted of an intensive sampling from June to September 2017, followed by a monthly sampling at two selected beaches of the sampling area (ongoing since October 2018), using a trawl net of 10-20mm. Four out of the five classes of the phylum Cnidaria were found: Hydrozoa, Anthozoa, Scyphozoa and Cubozoa. Ten species were recorded, eight species from four different genera: Cyanea sp. 1 and sp.2, Chirodropus palmatus(?), Catostylus tagi, Catostylus sp. 1, sp. 2, and sp. 3 and Staurostoma mertentii. Two species remained unidentified: one hexaradial jellyfish and a group of organisms under the family Rhyzostomatidae with fused oral arms on younger animals and club-like appendages on bigger ones. Monthly records show that species of the class Cubozoa are dominant from late November/early December to May at both sites; while C. tagi occur throughout the year but are dominant between September and November. High number of ephyrae were counted among the sample. Physical-chemical parameters recorded-temperature, salinity, pH, Conductivity, turbidity, dissolved oxygen and TDS salinity varied between 27.80-31.74°C, 14.40-25.77, 8.18-10.12, 25-40.37μS/cm, 4.18-87.50NTU, 8.94-36.30mg/L, 14.50-24.63g/l respectively. This study is one of the first along the coastline of Cameroon and will need additional investigations using molecular techniques to confirm species identity and genetic diversity. Aspects of ecology and biochemistry are also envisaged.
Microplastic ingestion in *Pelagia noctiluca*

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Marine plastic pollution is becoming a problem of growing concern to the scientific community, environmental policy makers and society. So much so that our age is referred to as the “Plastic Age”. Microplastics in particular represent a serious problem because, due to their size, they can be ingested by marine organisms and pass through food webs. In addition to the damage that ingestion cause, microplastics adsorb chemical contaminants that can be endocrine disrupters, and the effect they can have on the health of organisms is unknown. The ingestion of microplastics has been documented in numerous species of marine mammals and birds, fish, mollusks, crustaceans and corals, among others. This work is the first study that evidences the ingestion of plastics and microplastics in *Pelagia noctiluca*. 
What drives massive apparition of the Gelatinous Plankton on the Moroccan Atlantic continental shelf?

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Since the nineties, more frequent massive apparitions of gelatinous macro-plankton species such as the ctenophores, jellyfishes and tunicates, are observed in the Moroccan Atlantic waters. A set of macro-plankton observations carried out during oceanographic surveys conducted on the Moroccan Atlantic continental shelf from 1992 to 2017 is used in this study to explore the occurrence of this phenomenon in time and space. An abundance index is calculated in the sampling stations and was weighted against the average number of stations per sea cruise for each survey. The results show that the maximum accumulated density of jellyfish and other gelatinous species over the whole period is mainly located in the area of strong permanent upwelling (22°N-23°N), and in the area of moderate permanent upwelling (31°N-33°30’N). Appearance of those species are more marked during the years 2007, 2009, 2011, 2015, 2016 and 2017. The preliminarily results let hypothesize that macro-plankton occurrence likely increase where and when some particular environmental conditions take place.
Dietary analysis of polyps and ephyrae of the moon jellyfish *Aurelia coerulea* based on high-throughput sequencing

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Dietary studies of polyps and ephyrae are important to understand the formation and magnitude of jellyfish blooms and provide important insights into the marine food web. However, the diet of polyps and ephyrae \textit{in situ} is largely unknown. Here, prey species of the polyps and ephyrae of the moon jellyfish *Aurelia coerulea in situ* were identified using high-throughput DNA sequencing techniques. Our results show that *A. coerulea* polyps and ephyrae consume a variety of prey items. The polyps consume both planktonic and benthic prey, including hydromedusae, copepods, ciliates, polychaetes, stauromedusae, and phytoplankton. *A. coerulea* ephyrae mainly feed on copepods and hydromedusae. Gelatinous zooplankton, including *Rathkea octopunctata* and *Sarsia tubulosa*, were frequently found as part of the diet of *A. coerulea* polyps and ephyrae. The utilization of high-throughput sequencing technique is a useful tool for studying the diet of polyps and ephyrae in the field, complementing the traditional techniques towards a better understanding of the complex role of gelatinous animals in marine ecosystems.
EATING OUT & SHOPPING
The V&A Waterfront in the harbour (close to the City Centre) is a vibrant hub with hundreds of shops and great restaurants. The Watershed in the Waterfront is where you will find local design. Visit www.waterfront.co.za for more information.

Greenmarket Square is in the heart of the city center is the place to browse for African Crafts. There is also the Pan African Market on Long Street. Negotiating prices/haggling on the markets is the norm!

MONEY MATTERS
The local currency is South African Rands. We recommend that you draw some cash at the ATM machines at the airport on arrival as there may not be a machine or bank close to your accommodation. You need cash for transport and to shop at markets but Visa/Mastercards are accepted everywhere.

ELECTRICITY
The South African electricity supply is 220/230 volts AC 50 HZ. Most plugs are 15 amp 3-prong or 5 amp 2-prong, with round pins. If an adaptor is needed, they can be purchased locally. US-made appliances may need a transformer. Most hotel rooms have 110 volt outlets for electric shavers and appliances.

EMERGENCY & MEDICAL SERVICES
National Police Services: 10111
Ambulance: 10177
All emergencies from a mobile phone: 112

WEATHER
November is Spring time in Cape Town! The average temperatures could be between 18 and 23 Degrees Celsius (64 – 73 Fahrenheit). We sometimes experience all four seasons in one day! It can get windy, so bring a warm jacket, umbrella and sunscreen.
GETTING AROUND
When travelling to Cape Town, you land at Cape Town International Airport. The airport is situated approximately 22 minutes, 18.5km drive to Cape Town city center, where the conference venue as well as hotels are situated. The easiest way to get to Cape Town city center from Cape Town International airport is make use of the shuttle service. Select this on your registration. The cost thereof is for your own account. Should you choose to drive yourself, make sure to book car hire before arriving in Cape Town in order to secure a vehicle.

NB: One cannot ‘hail’ a cab or taxi in Cape Town in the street. Restaurants and hotels or guest houses are happy to order one for guests via phone. You can also book a ride for airport transfers or to get around town with Uber and Taxify.

GRATUITIES
Although guided by the service received, as far as tipping and gratuity etiquette goes, a standard of 10% of the total bill is usually calculated when squaring up.

Check your bill. Sometimes the tip is included in the total (if there are 10 people or more at your party then you will almost surely have the tip included in your bill).

It is not advised to leave the money on the table; hand it to the waiter or waitress that served you.

Useful hint: Use your coins / loose change for tipping even when paying with a credit card.

SAFETY
It is safe to walk most places during the day. However, walking alone at night is not recommended. Rather take a taxi. You may be approached by people in the streets begging for money. It is your personal choice to give them money or not.

However, the Cape Town Central City Improvement District (CCID) campaigns that people should rather support the work of those NGOs and shelters that offer street people an alternative to life on the streets.
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