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BOOK OF ABSTRACTS

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Opening Plenary Speaker

New dawn fades – returning to dark data during a zooplankton technology revolution

Angus **Atkinson**

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Traditional zooplankton study methods like ship-based fieldwork, microscopy and long-term monitoring are all facing multiple challenges. At the same time, new technologies and abilities to process large data volumes are revolutionizing how we observe plankton. These exciting developments are providing very different views of plankton, often at much higher resolution than the scales typifying climate change effects. To complement these new approaches, this talk emphasizes the compilation of old in-situ observations, the meta-analysis of large datasets and networking of time series. By using the in-situ variability across basin-scale gradients and multi-decadal timescales we have a natural laboratory, shedding light on the mechanisms behind large-scale change. Nowhere is climate change more obvious than at the poles, and this talk focuses on polar-, and mainly Southern Ocean, zooplankton. I will describe work on Antarctic krill, copepods and salps, contrasting both their responses to climate change and how they contribute to the Biological Carbon Pump. Polar observations will be set into global context, using biomass size spectra to examine how efficiently zooplankton channel energy from algae to higher predators. This reveals the dominant mechanism by which declines in phytoplankton are amplified through successive trophic levels. Both size-based and taxonomically-based approaches are revealing zooplankton resilience and step changes, with responses often far-removed from what might be predicted simply from direct, temperature-based responses. These ‘unexpected’ responses pose major challenges to projecting pelagic ecosystems in a warmer world and I discuss complementary approaches from both traditional and emerging techniques to address this.

Session 1: Roles of gelatinous zooplankton in ecosystems: Production, population dynamics, trophic interactions and biogeochemical cycling

Convenors:
Cornelia Jaspers (Denmark), corresponding
Alexis Bahl (Canada)
Richard Brodeur (USA)
Evgeny Pakhomov (Canada)
Kylie Pitt (Australia)

Invited Speakers:
Mary Beth Decker (Department of Ecology & Evolutionary Biology, Yale University, New Haven, USA)
Fabien Lombard (Sorbonne Université, Laboratoire d'Océanographie de Villefranche, Villefranche-sur-Mer, France)

Gelatinous zooplankton, such as ctenophores, jellyfish, and pelagic tunicates (larvaceans, salps, pyrosomes, and doliolids) are widespread in marine ecosystems and contain groups belonging to the fastest-growing metazoans on earth. Due to their unique feeding strategies and interactions with other organisms, these groups have significant impacts on carbon export, nutrient cycling, and transfer of energy in marine ecosystems. Irrespectively, gelatinous zooplankton remain understudied compared to crustacean taxa and are often disregarded in food web investigations. Gelatinous zooplankton are notoriously difficult to sample due to their soft body texture and patchy distribution, limiting our understanding of their behaviour and ecophysiology. Nonetheless, this view is slowly changing, and accumulating evidence shows that gelatinous zooplankton may be more important to trophic transfer and nutrient cycling in the ocean than previously thought. Moreover, recent modeling efforts incorporating gelatinous zooplankton suggest that their impact on ecosystem structure and function can, at times, be high. This is reinforcing the need for an improved understanding of gelatinous zooplankton and their impacts on marine food webs and carbon cycling.

This session invites a diverse set of researchers from different career stages to present their latest findings on gelatinous zooplankton, including their physiology, biogeography, behaviour, genetics, ecology, and biogeochemistry. We especially encourage presentations focusing on the role of gelatinous zooplankton in ecosystems and how this may change in the future. Topics covering population dynamics to blooms and bio-invasions are welcome. We highlight the need for presentations that deal with long-term data in order to determine population trends and potential future impacts on trophic transfer and carbon export of all gelatinous zooplankton groups ranging from microscopic larvaceans to macroscopic salps and scyphomedusae. Presentations of field investigations in combination with experimental approaches, and modeling studies that quantify evolutionary changes in response to selective pressures are amongst the priority topics of this session. We aim to provide a forum to discuss the latest research results, exchange ideas and collaborate to advance our understanding of gelatinous zooplankton and their role in marine ecosystems now and in the future.

S01-17140 Invited

Ubiquity of inverted 'gelatinous' ecosystem pyramids in the global ocean

Fabien **Lombard** [1,2,3*], Lionel Guidi [1,2*] , Manoela C. Brandão [1,2], Luis Pedro Coelho [4,5,6], Sébastien Colin [7], John Richard Dolan [1], Amanda Elineau [1], Josep M Gasol [8], Pierre Luc Grondin[9], Nicolas Henry [2,10], Federico M Ibarbalz [2,11], Laetitia Jalabert [1], Michel Loreau [12], Séverinne Martini [1,13], Zoé Mériguet [1], Marc Picheral [1], Juan José Pierella Karlusich [2,11], Rainer Pepperkok[14,15], Jean-Baptiste Romagnan [1,16], Lucie Zinger [2,11], Lars Stemmann [1], Silvia Acinas [8], Lee Karp-Boss [17], Emmanuel Boss [17], Matthew B. Sullivan[18], Chris Bowler [2,11], Colomban de Vargas [2,19], Eric Karsenti [2,11,20], Gabriel Gorsky [1,2]

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Plankton are essential in marine ecosystems. However, our knowledge of overall community structure is sparse due to inconsistent sampling across their very large organismal size range. Here we use diverse imaging methods during the Tara Ocean cruise to establish complete plankton inventories of organisms across 5 orders of magnitude in size (15 in biovolume). Plankton community size and trophic structure variation validate a long-held theoretical link between organism size-spectra and ecosystem trophic structures. Unexpectedly, bottom-heavy ecosystems (the norm on land) appear to be rare in the ocean. Rather, we found that predator/grazer biomass and biovolume typically exceed that of primary producers at most (55%) locations, likely due to our better quantification of gelatinous organisms. Collectively, gelatinous organisms represent 30% of the total biovolume (8-9% of carbon) of marine plankton communities from tropical to polar ecosystems. Communities can be parsed into three main types: diatom/copepod-dominated in eutrophic blooms, rhizarian/chaetognath-dominated in oligotrophic tropical oceans, and gelatinous-dominated elsewhere. While plankton taxonomic composition changes with latitude, functional and trophic structures mostly depend on the amount of prey available for each trophic level. Given future projections of tropicalization and oligotrophication of marine ecosystems, our findings suggest that rhizarian and gelatinous organisms will increasingly dominate the apex position of planktonic ecosystems, and lead to significant alterations in the ocean's carbon cycle.

S01-17403 Invited CANCELLED

~~Population fluctuations of Bering Sea scyphomedusae their ecological roles in a productive shelf ecosystem~~

~~Mary Beth **Decker**[1], Richard Brodeur[2], Lorenzo Cianelli[2], James Ruzicka[3]~~

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~~Globally, there have been few long-term, shelf-wide surveys of jellyfish that have allowed for the examination of how populations might respond to changing climatic and oceanographic conditions. In the eastern Bering Sea, jellyfish biomass, primarily that of the scyphozoan *Chrysaora melanaster*, has fluctuated dramatically since 1982, when systematic collections of these medusae began, with the timing of the jellyfish biomass increases and declines coinciding with transitions between climatic regimes. Jellyfish increases during 1982-2004 were influenced regionally by a suite of physical and biological factors, such as, sea-ice cover, sea-surface temperature, currents, wind mixing, and food availability. Reanalysis of an updated time series for the period 1982-2017 reveals that models using only physical parameters accurately described recent trends in Bering Sea jellyfish biomass. Jellyfish biomass did not increase during warm periods, as has been speculated to occur elsewhere. We examined the role of *Chrysaora* as ecosystem structuring agents by: (1) estimating impacts of jellyfish variability throughout the food web via end-to-end ecosystem models, and (2) using pelagic survey data to examine interannual relationships between dietary and spatial overlap of jellyfish and forage fishes. *Chrysaora* were not a major consumer of zooplankton production, but they were important predators upon specific zooplankton groups including pteropods, microzooplankton and gelatinous zooplankton. We found that the impact of *Chrysaora* upon groups that prey heavily upon these plankton classes, such as juvenile salmon, to be greater than the impact of *Chrysaora* upon forage fish.~~

S01-17087 Oral

Early spring *Salpa thompsoni* population dynamics in the Atlantic sector of the Southern Ocean

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Pelagic tunicate species, *Salpa thompsoni*, is conspicuous in the Southern Ocean and accounts for a large portion of the zooplankton. While salp functional role in pelagic ecosystems is recognized, their life cycle during winter and spring remains poorly understood. With an aim to uncover the effects of environmental drivers on *S. thompsoni* population dynamics, we collected physical oceanography and salp population development data in the Atlantic sector of the Southern Ocean during austral spring 2022. Salp abundances were low, i.e. < 10 ind.m^{-2}, in the 0-200 m and 0-600 m layers. The *S. thompsoni* population was at the most advanced stages of development, including a diverse stage composition and a bimodal size distribution, in sub-Antarctic waters north of the Antarctic Polar Front (APF). This indicated ongoing salp reproduction. Stations located in Antarctic waters south of the APF were characterized by very low salp densities (generally < 2 ind.m^{-2}) and early developmental stages. The distribution of biologically diverse salp populations and their development were strongly influenced by the regional physical oceanography. The strong currents and dynamic frontal systems, including eddies, that make up this region appear to be a major driver defining salp demographic development and densities. It appears that salps north of the APF likely spawn year-round, while salp populations in regions influenced by Antarctic waters show strong seasonal development and their reproduction may stop during the austral winter.

S01-17099 Oral (ECOP)

Unveiling ecosystem health through Gelatinous Zooplankton indicators

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In recent decades, gelatinous zooplankton (GZ) have emerged as intriguing biological components of ocean ecosystems, drawing attention for their multifaceted roles. Despite increasing recognition, the ecological significance of GZ often remains oversimplified and misunderstood. While their propensity to form blooms has raised concerns about their role as indicators of ecological disruption—e.g. voracious feeding inducing a zooplankton stock decrease that subsequently affects the small pelagics stock—they also play a pivotal role in ecosystem dynamics, specifically in the trapping and sinking of organic matter to the deeper layers of the ocean.

Our study leverages six routine fishery trawl surveys conducted in French marine ecosystems since 2016 to compile a comprehensive dataset encompassing GZ's diversity, distribution, abundance, and biomass. The development of abundance/biomass indices allows for the standardisation of the number and weight of GZ individuals captured per trawl and per taxon, facilitating meaningful comparisons across surveys.

This standardised dataset could be an important resource in the context of the Marine Strategy Framework Directive, which aims to assess and safeguard European marine ecosystems and biodiversity through the use of ecosystem indicators. To adapt to the unique characteristics of GZ data, we have customised three specific indicators for pelagic communities: PH1, based on functional groups; PH2, focusing on total abundance and/or biomass; and PH3, focusing on diversity indices. This adaptation enables the inclusion of gelatinous species in the assessment of Good Ecological Status in European waters, highlighting their intricate role within marine ecosystems and emphasising the significance of ecosystem indicators in ecological research.

S01-17120 Oral (ECOP) **CANCELLED**

~~Size-dependent Global Distribution of *Gelatinous Thaliaceans* Driven by Current Velocity? From case study in the South China Sea~~

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~~Thaliaceans are widely distribute in the global ocean, and they play an important role in the biological carbon pump and marine food web by forming dense swarms, having high feeding rates, and producing fecal pellets and carcasses. The contribution of thaliacean swarms to the downward transport of carbon depends not only on their abundance but also on their body size. To identify the key factors that determine the zoogeographical distribution and abundance of size-dependent thaliaceans, three cruises were conducted in the South China Sea (SCS) from early stage of before the southwest monsoon (pre-SWM) in 2009 to the peak of the northeast monsoon (peak-NEM) in 2010. Our results revealed that high thaliacean abundance occurred consistently with high chlorophyll a concentration, stimulated by hydrodynamic processes. The large-sized thaliacean species tended to occur in the open ocean where current velocity was generally low, whereas small-sized species were found in coastal areas with generally high current velocity. Cluster analysis and linear regression analysis demonstrated that the current velocity was the key factor that control shaped the size-dependent zoogeographical distribution of thaliaceans. Furthermore, we mapped the global distribution of typical thaliaceans with different sizes and predicted the key environmental factors affecting their distribution at global scales based on global databases of thaliacean occurrence, current velocity, temperature, and salinity. The results indicated that global warming-induced changes in surface current velocity may alter the size-dependent zoogeographical distribution and community composition of thaliaceans, thereby affecting the biological carbon pump and marine ecosystem. Overall, this study sheds light on the way in which pelagic tunicates respond to global change through changes in hydrodynamic conditions.~~

~~Keywords：Thaliacean，Zoological distribution，South China Sea, Global ocean~~

S01-17132 Oral (ECOP)

Baleen whales of the plankton: Larvaceans can enhance trophic transfer and carbon sequestration

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Even though gelatinous zooplankton have lately attained large public attention, their recognition as a trophic link in the food web remains underappreciated. This is especially so for larvaceans. Larvaceans span several orders of magnitude in body size and further secrete external feeding structures (houses) that can reach maximum sizes of 2 m for giant deeper living species. These houses are regularly discarded and thereby larvaceans produce large amounts of marine snow that are important for carbon cycling and sequestration. But most importantly, larvaceans are Baleen whales of the plankton as they short-cut marine food webs by feeding directly on the smallest primary producers, which are unavailable to most other mesozooplankton groups. Combined with their high growth rates, larvaceans can contribute more to secondary production compared to copepods across environmental gradients in marine systems. This is exemplified for the Indian Ocean, including the continental shelf off tropical NW Australia. Estimates of secondary production in this area highlight the importance of gelatinous larvaceans in comparison to classical crustacean zooplankton to trophic transfer, especially in tropical, sub-tropical and oligotrophic areas. I will close by discussing the current and potential future role of larvaceans in the Anthropocene as they can directly eat small phytoplankton that are predicted to become more prevalent under climate change. This could potentially moderate projected future declines in ocean productivity and fisheries.

S01-17135 Oral (ECOP)

Gene expression patterns of *Salpa thompsoni* reveal remarkable differences in metabolism and reproduction near the Antarctic Polar Front

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Salpa thompsoni is an important grazer in the Southern Ocean and most abundant in the Antarctic Polar Front (APF) region. During recent decades, their distribution expanded southwards. However, it is unclear whether salps can maintain their populations in the high Antarctic regions throughout the year due to a poor understanding of their physiological responses to changing environmental conditions. We examined gene expression signatures of salps collected in two geographically close regions south of the APF that differed in water mass composition and productivity. The observed differences in the expression of genes related to reproductive, cellular and metabolic processes reflect variations in water temperature and food supply between the two regions studied here. Recent studies have shown that the sexual reproduction of blastozooids may suffer from unfavourable conditions. Our analysis focused on small oozoids and therefore provides the first evidence that asexual reproduction in salps may also be affected in response to low water temperature and food conditions. Our study contributes to a better understanding of the physiological responses of *S. thompsoni* to changing environmental conditions, and how the species may adapt to a changing environment through potential geographic population shifts under future climate change scenarios.

S01-17150 Oral (ECOP)

Siphonophores in the global ocean: Clouding acoustic estimates of fish biomass, and contribution to carbon flux

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Mesopelagic fish may be the last major untapped source of protein on the planet. Estimates of global mesopelagic fish biomass are as high as 16 billion tonnes, but there is major uncertainty around this because the acoustic data scaled to fish biomass may in fact contain echoes from siphonophores. Siphonophores are gelatinous zooplankton with low individual dry mass, but physonect and some cystonect siphonophores are strong acoustic targets because they possess gas bladders – pneumatophores (filled with CO) – used for buoyancy. Recent findings have estimated that up to 50% of the backscatter attributed to fish could in fact be due to siphonophores. We are developing a database of global siphonophore distribution and using it to model the 3D distribution of siphonophore species and richness globally and by depth. Predicting acoustic backscatter from this distribution (solving the so-called acoustic 'forward problem') will enable us to reduce in a spatially explicit way bias to acoustic estimates of fish biomass, thereby enabling a more accurate estimate of mesopelagic fish biomass based on acoustics. Our database also enables us to explore spatially the likely contribution of siphonophores to carbon flux.

S01-17168 Oral (ECOP)

The controlling effect of benthic ecosystem on the harmful jellyfish blooms by promoting the polyp colony development under global change

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In recent years, the harmful jellyfish blooms in many seas around the world have caused serious damages to fishery resources, human health, coastal industry and ecosystem balance. It is difficult to accurately explain and predict the jellyfish population dynamics by integrating the changes of water column environment and routine investigation of jellyfish adults, so the importance of polyp stage and the benthic ecosystem was brought into attention. Firstly, at the individual and population levels, we explored the effects of bottom temperature variations in winter and spring on the asexual reproduction of polyps through laboratory experiments. Secondly, at the community level, we investigated the adaptation mechanism of polyps in the benthic ecosystem by in-situ monitoring the population dynamics of *Aurelia cuerulea* polyps and other benthic invertebrates in Jiaozhou Bay. The results showed that the variation of bottom temperature during wintering period and spring affected the asexual reproduction of polyps from energy accumulation, low temperature stimulation, strobilation stimulation, and duration of suitable temperature for ephyra release. The increased temperature promoted the asexual reproduction of polyps and their colonization on artificial substrates. At the same time, invertebrate organisms invaded the polyp population according to different reproductive colonization methods and physiological characteristics, and produce severe spatial competition. Our study suggests that in order to fundamentally manage the harmful jellyfish blooms under global change and coastal constructions, we should focus on the adaptive mechanism of jellyfish polyps, the transform of interspecies interactions, and the response of local benthic ecosystems.

S01-17235 Oral

Unraveling population dynamics and local Adaptation in blooming *Cyanea capillata* jellyfish: improvements for Baltic and North Sea management

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Understanding of population structures, connectivity and dispersal of biota is vital for biodiversity conservation. Yet, it is often lacking for gelatinous zooplankton due to methodological challenges as their occurrence and blooms usually show large spatiotemporal variation. Such variation in occurrence in time and space can result from reproduction and growth of new individuals in a given location, from redistribution of individuals to another location, or a combination of both. Dispersal can contribute significantly to population structure by affecting reproduction, growth, gene flow and, ultimately, species persistence, but knowledge of vectors and dispersal paths is often scarce. Here, we use *Cyanea capillata* as a model organism to show how population genetic analysis can be coupled with Lagrangian dispersal simulations to provide crucial information on the population structure. The analysis was based on a large sample and data set with detailed metadata on the life stage, the geographic position of specimens together with abiotic information which are often missing from publicly available sequence data. We identified two distinct populations of *C. capillata* in the Baltic Sea/North Sea region, which points to a successful local reproduction and a self-sustaining Baltic Sea population thus solving a long-standing riddle regarding the status of the Baltic Sea population. Our findings can help to improve forecasting of jellyfish bloom events and enhance predictions of future scenarios, but also raise questions regarding the extent of local adaptations.

S01-17290 Oral (ECOP)

Estimating the influence of *Salpa thompsoni* migratory behavior on carbon export in the Southern Ocean: a stage- and size-specific approach

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Salpa thompsoni, the most abundant tunicate species in the Southern Ocean, has an obligatory two life cycle stage (LCS, blastozooid and oozoid) and exhibits stage- and size-specific daily vertical migration (DVM) behavior. Contributing to the biological carbon pump, DVM constitutes a major pathway for transporting particulate organic carbon (POC) from surface waters to depth. In the past, the impact of *S. thompsoni* on carbon export has generally been inferred from surface fecal pellet production rates and sinking potential of fecal pellets. Such estimates were provided in less than two dozen studies and none of them accounted for DVM. This study presents a novel empirical model to estimate the influence of *S. thompsoni* stage- and size-specific migratory behavior on the POC (fecal pellets) flux, based on individual day and nighttime depth residence estimates. Utilizing discrete salp depth distribution and abundance data from six locations across the Southern Ocean during 1989-2018, we begin by estimating individual day and night vertical salp distribution according to LCS and body size. Using temperature adjusted allometric equations, and residence depth chlorophyll-a, as a proxy for prey availability, we model stage- and size-specific ingestion and gut clearance rates to derive pellet egestion rates. The output provides daily estimates of POC flux by depth. This study advances our understanding of the ecological role of *S. thompsoni* DVM in carbon transport, highlighting the significance of individual behavior and life cycle stages in shaping carbon flux in the Southern Ocean.

S01-17296 Oral

Quantification of gelatinous zooplankton along the Seward Line in the Northern Gulf of Alaska

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The quantification of gelatinous zooplankton is a challenging aspect of describing zooplankton communities as compared to the crustacean component of the pelagic realm. Here we describe the absolute and relative contribution of the major epipelagic gelatinous groups over the past 25 years of surveys along the Seward Line in the Northern Gulf of Alaska. Observations are based upon an array of sampling tools that include fine-meshed nets for larvaceans and pteropods, traditional nets for meso-jellyfish and chaetognaths, and small trawl nets for the macro-jellyfish. We will present the changes in composition and contribution of each group along our 250-km cross-shelf transect, between seasons, and across years. Although biodiversity within each gelatinous group is low, strong shifts occur across each spatial and temporal dimension. By making a first order estimate of the production within each group, we will elucidate the likely pathways of matter through the entire zooplankton assemblage within this productive sub-polar habitat.

S01-17326 Oral (ECOP)

Short-term but large biomass bloom of *Pelagia noctiluca* medusae shoals in the coastal waters as an ecological indicator: Research gaps and future scope

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Pelagia noctiluca plays a vital role as an ecological indicator, helping researchers and conservationists assess the health and stability of marine ecosystems. Their presence, abundance, and behavior can provide crucial insights into various environmental factors, making them valuable tools for monitoring and managing the impacts of human activities and environmental changes on the ocean. During our reef surveys, a large biomass of *P. noctiluca* medusae shoals stretching several kilometers was observed from Mandapam region under the Gulf of Mannar Marine Biosphere Reserve (GoMMBR), Southeast coast of Tamil Nadu, India. Video transect method was performed and found >100 (1 km away from bloom) to several thousand medusae shoals (bloom spot) in the coastal waters. The impacts of short-term but large biomass bloom of *P. noctiluca* medusae shoals on fishing activities, coral reef research, and plankton studies, are highlighted. This rare bloom event in the GoMMBR waters indicates an ongoing environmental changes and nutrient availability. However, several research gaps still remain to address various research questions about the prevalence, outburst, and short-term role of *P. noctiluca* medusae shoals in complex trophic ecology and biogeochemical cycles. Further, commercial harvest of *P. noctiluca* medusae shoals can be explored to extract light emitting proteins and collagen for various biomedical applications.

Keywords: *Pelagia noctiluca*; Coral Reefs; ecological indicators; Carbon sequestration; Gulf of Mannar.

S01-17342 Oral

Tracking the invasion: Long-term trends in density, size, and sex ratio of *Blackfordia virginica* in a non-indigenous environment

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The hydrozoan *Blackfordia virginica* is an invasive species already found in several non-indigenous environments, particularly in the Guadiana River estuary located in the southeast of Portugal, where it was recorded for the first time in 2008. During the first years, its density presented a high interannual variability probably linked to freshwater river inflow, with some years registering null observations of the medusa phase. Thus, it is important to monitor the evolution of *B. virginica* population dynamics through time to keep on track its invasion. From 2014 until 2021, zooplankton hauls were conducted monthly in the middle estuary of Guadiana River to determine medusae density, size and sex ratio. During 2014, there were no medusae registered while in 2015 onward density stabilized with a total average of 26.2 ± 119.5 ind m^{-3}, reaching a maximum value of 976.1 ind m^{-3} in July 2021. They occurred between May/June until October/November (December in 2017), usually related to temperature and salinity. The overall size range was between 1 and 20 mm, with smaller sizes found in May (2 ± 0.9 mm) where all medusae were still immature, while the rest of the months showed a wide variability of sizes. Considering all sampling period total female/male ratio was 1.0:1.9 with sizes ranging from 3 to 20 mm. Concluding, the *B. virginica* has established its population in the Guadiana River estuary which may be related to the reduction/regulation of the freshwater river inflow due to Alqueva dam also associated with dry climate.

S01-17360 Oral

Upwelling event response, structure of the food web in a shallow coastal upwelling embayment

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The St Helena Bay is the most productive bay in the Benguela ecosystem on the west coast of South Africa, and had been studied since the 1950s. Upwelling, oxygen and nutrient concentrations in sub thermocline water displayed pronounced decadal-scale variability (Hutchings et al. 2012). Primary production is highly variable along the line but appeared higher than the value observed over the shelf. Zooplankton variations showed during the 1950-2010 period a strong relation with the community of small pelagic fish. In order to follow small temporal scale, 8-day samplings in early summer (nov-dec) 2016 were conducted off Elands Bay along the St Helena line. Taxonomic composition of the zooplankton community, settled volumes of five size fractions (125-250 µm, 250-500µm, 500-1000 µm,1000-2000 µm, >2000 µm), as well as isotopic composition of the whole planktonic community was analysed. Net community <500 µm was largely dominated by the large diatom *Coscinodiscus giga*s and increased with time, while zooplankton >500 µm remained constant. Zooplankton biodiversity was rather low, and taxa were well distributed into the different size classes. Copepods were mostly present in the 500-1000 µm size classes, then chaetognaths and hydromedusae in the size 1000-2000 µm and then ctenophores above. New data on hydromedusae diversity is presented. Isotopic signatures displayed a clear trophic enrichment from POC to Ctenophores. Impact of short scales changes in the upwelling dynamic ont the food web structure is then discussed.

S01-17364 Oral

Modeling studies of dynamics, blooms and secondary production of jellyfish in light of climate change

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A pelagic-benthic combined life histiry together with dynamic ocean conditions often leads to challenges for mechanistically understanding great spatio-temporal variations of jellyfish population dynamics, which limit further assessing the role of jellyfish in trophodynamics and carbon cycling in the oceans. While mechanistic modeling provides useful tools for the study of jellyfish population dynamics, up to now very few modeling afforts have incorporated a whole life cycle and stage-specific structures of jellyfish populations with fine-scaled ocean conditions into estimation of jellyfish secondary production. In this talk we will introduce a population model of *Aurelia* sp. developed with a full life cycle and fine-scaled ocean conditions in the northern Gulf of Mexico, then display model applications to examination of spatio-temporal dynamics, blooms and secondary production of jellyfish populations, and further discuss the blooms defined as abundance or biomass and potential implications to ecosystem dynamics and fisheries production in the oceans.

S01-17395 Oral (ECOP)

Investigating life-stage specific doliolid distributions in relation to water column structure in the South Atlantic Bight

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Continental shelves are biological and variable systems that experience pulses of nutrient input due to frequent upwelling of nutrient-rich deep waters. Pelagic tunicates and other gelatinous, filter feeding grazers are often associated with newly upwelled waters on continental shelves due to their ability to bloom by asexual reproduction. Doliolids, an order of pelagic tunicates most common on subtropical shelves, periodically form dense blooms (>1,000 zoids m^{-3}) that may substantially alter available trophic pathways by intensifying the microbial loop due to the production of relatively buoyant fecal pellets and carcasses. Most studies, however, of doliolid ecology are limited to plankton net sampling, which average their abundance vertically and likely underestimate abundances, particularly in non-bloom situations. To better understand the origin and drivers of doliolid blooms on continental shelves, we collected *in situ* imagery data and parameterized fine-scale physical conditions at monthly intervals on the mid-shelf of the South Atlantic Bight in 2021-2022 to capture a wide range of natural conditions. We examined life-stage specific distributions of doliolids to assess if doliolids were consistently reproducing within mid-shelf water-masses and the potential differences in habitat preferences between reproductive stages. Highest abundances were observed during the summer but, all reproductive life-stages were present throughout the year suggesting that these animals continually reproduce regardless of favorability of conditions. Resolving life-stage specific spatial niches across a wide range of conditions may help improve prediction of neritic tunicate blooms and their influence on broader properties of marine food webs.

S01-17400 Oral

Species diversity and distribution of net-collected planktonic cnidarians in the deep basins of the Arctic Ocean

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The taxonomic composition, and quantitative vertical and horizontal distribution of gelatinous zooplankton (hydromedusae and scyphomedusae) was studied using plankton nets collections from 8 expeditions of the research icebreakers Polarstern (1998-2016) and USCGC Heal*y* (2005). The area under study covers the oceanic environments of the Arctic Ocean, specifically the deep Nansen, Amundsen, Makarov and Canada basins. The species inventory is based on original records from >150 locations where stratified sampling of the entire water column from the bottom to the surface was conducted with Multinet Midi (mouth opening 0.25 m^2) and Multinet Maxi (mouth opening 0.49 m^2). A total of 21 species of hydromedusae and 4 scyphomedusae were identified in the examined collections. Seventeen species of hydromedusae from our list have been previously recorded in the deep Arctic basins; the other 4 species were recorded for the first time. Most of the studied taxa are holoplanktonic, meso-bathypelagic and bathypelagic, and all but one are oceanic species. The species diversity of cnidarians is clearly increasing with depths. Vertical distribution patterns and population size structure of hydromedusae species are described for the most abundant species. The numerical abundance, diversity, and biomass of net-collected cnidarians suggest them to be a critical link in the Arctic pelagic ecosystem, yet their responses to a changing climate and changing ocean conditions are mostly unknown.

S01-17463 Oral (ECOP)

Size-based changes in trophic ecology and nutritional quality of moon jellyfish (*Aurelia labiata*)

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The role of jellyfish in marine food webs is gaining attention, but the nutritional value of jellyfish to higher trophic levels remains poorly understood. In this study, we aimed to determine the relationship between jellyfish size, diet, and nutritional quality. We measured stable isotope (SI) and fatty acid (FA) profiles of particulate organic matter (POM), plankton size classes, and 152 *Aurelia labiata* collected from a coastal site in British Columbia, Canada, in July and September 2019. According to FA trophic markers and chlorophyll-a concentrations, the POM was a mix of phytoplankton, microzooplankton, bacteria, and detritus. According to $\delta^{15}N$, POM was ~ 1 trophic level lower than plankton. Gelatinous zooplankton had low FA content (5-6 µg per mg dry weight) compared to non-gelatinous zooplankton (43-65 µg per mg dry weight). A Bayesian mixing model (MixSIAR) was used to assess the contributions of POM and plankton to *A. labiata* diet, which demonstrated a size-based shift from 40% plankton at 19 mm to 70-75% at 225 mm. Similarly, both $\delta^{13}C$ and $\delta^{15}N$ increased with size and *A. labiata* of 19 mm were ~ 1 trophic level lower than *A. labiata* of 225 mm. We also documented size-based changes in nutritional quality of *A. labiata*, where C:N decreased with *A. labiata* size, and essential FAs ARA and DHA increased with size. Overall, these findings emphasize the importance of considering jellyfish size when evaluating nutritional pathways through jellyfish in marine food webs, and support that diet is one important driver of jellyfish biochemical composition.

Keywords: Bayesian mixing model; fatty acid; marine food web; nutrition; stable isotope

S01-17044 Poster

Mucous-mesh grazer in the Benguela and Humboldt Upwelling Systems

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The contribution of mucous-mesh grazers such as Thecosomata (Pteropoda) and Thaliacea in zooplankton biodiversity monitoring was overlooked in the past mainly due to methodological constraints for sampling, preservation, identification, and lack in taxonomic expertise. They can, however, play an important ecological role as Thecosomata are important grazers on microplankton and can contribute significantly to the organic and inorganic particle flux into the deep ocean through sinking mucous flocs, faeces, carcasses and aragonitic shells. Thaliacea (Tunicata), having among the highest reported growth rates of all multicellular animals, occasionally occur in massive blooms during which they graze large amounts of phytoplankton and microzooplankton, subsequently providing an enhanced carbon flux into deeper layers by sinking of faeces and dead and moribund animals. Nevertheless, the knowledge about mucous-mesh grazer is relatively fragmentary.

We will enlighten the role of mucous-mesh grazers as competitors for food in two Eastern Boundary Upwelling Systems, which are among the most productive marine ecosystems worldwide and support economically valuable commercial and culturally important artisanal fisheries. We detected 21 and 11 species of Thecosomata and 16 and 21 species of Thaliacea in the Benguela and Humboldt Upwelling Systems, respectively; 7 Thecosomata and 8 Thaliacea species were common in both systems. Thecosomata were mainly detected in the area of the shelf edges, where particle concentrations were high enough to provide sufficient food but still low enough to prevent clogging of the mucous nets. Salpida and Doliolida (Thaliacea) were occasionally detected in blooms in both regions.

S01-17067 Poster (ECOP)

The Northern California Current on fire: causes and consequences of a widespread and persistent anomalous pyrosome bloom

Richard D. **Brodeur**[1,2], Kelly R. Sutherland[3], Kim S. Bernard[2], Laura E. Lilly[4], Elizabeth A. Daly[4], Dylan G.E. Gomes[1], Samantha M. **Zeman**[4], Moira Galbraith[5], R. Ian Perry[5,6], Douglas L. Draper[1], James J. Ruzicka[7], Eric P. Bjorkstedt[8], and Roxanne R. Robertson[9]
*Presented by Samantha M. **Zeman** on behalf of Richard D. **Brodeur***

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Marine heatwaves (MHWs) have increased in intensity and duration globally as a result of sustained carbon emmissions. The North Pacific Ocean witnessed multiple strong and prolonged MHWs since 2014 leading to many ecosystem anomalies. Pelagic urochordates (salps and appendicularians) are dominant components of oceanic, low productivity waters globally and have been studied with some regularity in temperate ecosystems. However, colonial pyrosomes are generally restricted to oceanic tropical seas and far less studied. The subtropical cosmopolitan species, *Pyrosoma atlanticum*, has priodically been sampled off Southern California. With the advent of anomalously warm conditions due to the severe MHW in 2014, *P. atlanticum* started appearing in the Northern California Current (NCC), north of its known range, and following a strong El Niño in 2016, became the dominant component of pelagic surveys by 2017. These massive blooms impaired commercial fisheries and contanimated beaches, prompting public concerns. Due to the paucity of information on this species north of its normal range, we compiled existing and new data on horizontal and vertical distributions, habitat preferences, feeding ecology and grazing rates, and utilization by higher trophic levels. This information was assimilated into an end-to-end ecosystem model to examine impacts to the pelagic and benthic food webs and human utilization of this system. Since this tropical invader may become established in the productive coastal ecosystem of the NCC with predicted future warming of the North Pacific, understanding its ecology and potential impacts will fill critical gaps in our knowledge of the importance of this hitherto understudied species.

S01-17089 Poster

Spatio-temporal variability in metabolism of the Antarctic pelagic tunicate *Salpa thompsoni*

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The mass-specific metabolic rates of the Antarctic pelagic tunicate *Salpa thompsoni* Foxton, 1961 were studied during March-April of 1998 and March 2002. The study revealed a large variation in metabolic rates and attempted explaining their variability. The main factors driving variability included density of tunicates in incubation containers (incubation density, e.g. the salp mass per unit volume of the respirometer), diel/circadian rhythms in salps, and spatial variability of their metabolic performance related to the feeding conditions. The mass-specific respiration rates of both salp life forms (solitaries and aggregates) appeared to be independent of their body mass. The salp-specific respiration rates at 3°C were strongly negatively influenced by their incubation density ranging between 2.0 and 90.4 $gWW.L^{-1}$. Salp respiration rates adjusted to an incubation density of 3 $gWW.L^{-1}$ in both solitary and aggregate forms followed similar circadian rhythms with the mean respiration rates of 79.5 and 41.5 $\mu g\ O_2\ gWW^{-1}\ h^{-1}$, respectively. These specific respiration rates of S. thompsoni were assumed to be a statistical norm and were compared to actual field point respiration rates corrected for the salp density and diel variability during 1998 and 2002 near the Elephant Island, the South Orkney Islands, and in the Bransfield Strait. Calculated deviations from a statistical norm identified effects of food concentrations, i.e. proxy of the plankton community development and composition, on the salp population performance. Findings of this study highlighted the applicability of the metabolic theory in describing the salp ecological dynamics in the Southern Ocean.

S01-17156 Poster

Study on the feeding of *Palaemon gravieri* on *Aurelia aurita* polyps

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In order to control the outbreak of jellyfish population, we conducted a screening study on the predators of *Aurelia aurita* polyps to achieve the purpose of biological control of *A. aurita*. In the laboratory, more than 30 species of macrobenthos collected from the Liaodong Bay of the Bohai Sea in China were observed for their feeding on *A. aurita* polyps. The results indicated that *Palaemon gravieri* could feed on polyps in large quantities. Under the condition of water temperature of 17 °C -26 °C and salinity of 23-35, *P. gravieri* could rip off the polyps attached to the plate forcefully for feeding. It took about 5 seconds to finish feeding a polyp on average. The highest feeding rate of one *P. gravieri* on the polyps was 198 individuals in 18 minutes, with an average of 11 individuals per minute. The number of days after molting had a significant effect on its feeding rate ($P < 0.05$). *P. gravieri* did not eat polyps within 24 hours after molting, and the feeding rate was higher from 5 to 9 days and 15 days after molting. However, the effects of body length and water temperature on feeding rate were not significant ($P > 0.05$). This study determined the predators in the polyps period, which gives an important foundation for further research on ecological restoration and prevention of *A. aurita* blooms.

S01-17158 Poster (ECOP)

Southern Ocean salp migratory behavior - The influence of life cycle stage and body size

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The Southern Ocean salp species, *Salpa thompsoni*, has been recorded to undergo extensive daily migrations with the potential to increase carbon export. Its ability to rapidly reproduce and occur in large blooms may have lasting implications for recycling and exporting carbon. There is, however, a lack of knowledge on how it is portioned between two salp life cycle stages (LCS) and body sizes. With net data spanning from 1989 to 2018, from six locations across the Southern Ocean, this study showed LCS and size-specific impacts on the daily migration patterns of *S. thompsoni*. Small- and intermediate-sized individuals (≤24 mm in body length) performed more extensive daily vertical migrations (DVM) compared to large-sized individuals ≥24 mm. Also, asexually reproducing oozoids averaged a daily migration distance of ~52 m, while blastozooids performed an average migration of 120 m. Life cycle stage as a factor accounted for a ~57% difference in amplitude. Evidence of reverse migration was also found across all locations and was particularly evident in medium- and large-sized *S. thompsoni* individuals. With a random-intercept model that accounted for the spatial and temporal variation stemming from cruise and station sampling designs, this study reports estimates for each LCS and size class at the circumpolar scale. This study highlights the importance of considering LCS and smaller body sizes when estimating DVM and its role in the biological carbon pump.

S01-17273 Poster (ECOP)

Biomass and distribution of cnidarians and ctenophores in summertime Icelandic waters in relation to environmental variables and lumpfish distributions

Tyler Ellis Sharpton[1], James Kennedy[2], Anna Heiða Ólafsdóttir[2] and Teresa Sofia Giesta da **Silva**[2]
Presented by Sofia Giesta da Silva on behalf of Tyler Ellis Sharpton

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In the past two decades, the research interest in jellyfish (cnidarians and ctenophores) has increased worldwide as their essential roles in pelagic ecosystems have become more evident. Also, jellyfish are hypothesized to benefit from climate-change-induced warming waters. This study presents novel research on jellyfish biomass in Icelandic waters during the summer months from 2013 to 2022, where patterns and fluctuations in jellyfish biomass were assessed. Possible drivers were explored, including chlorophyll-a, lumpfish biomass, North Atlantic Oscillation index, salinity, temperature, and zooplankton biomass, along with analyzing lumpfish stomach samples to evaluate any prey-predator interactions. Data for this study was collected during the Icelandic Marine and Freshwater Research Institute's summer survey from 2013 to 2022. Generalized additive model results show that spatial and temporal covariates were found to explain the highest deviance of jellyfish biomass presence (26.5%), and environmental variables' influences on jellyfish biomass seemed to be highly region-specific. Lumpfish was an important predictor of jellyfish presence, explaining 4.94% of the deviance, followed by salinity (2.93%) and chlorophyll-a (2.49%). Stomach samples showed that jellyfish, crustaceans, and chaetognaths are present in the lumpfish diet. This research provides new insights into the ecology and distribution of jellyfish in Icelandic waters, its potential implications for the management of jellyfish in Icelandic waters, and their influences on lumpfish distributions.

S01-17310 Poster

Spatial characteristics of *Salpa fusiformis* in the surface waters of the western East/Japan Sea

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In order to understand the distribution characteristics of solitary blastozooid form of *Salpa fusiformis* with increasing frequency of occurrence, we investigated spatial heterogeneity of near-surface zooplankton using a Manta trawl (mesh size of 330 μm) and the related environmental factors on board *R/V Eardo* in the western East/Japan Sea from July to August in 2019. *S. fusiformis* distributed evenly along the center from south to north in the study area. *S. fusiformis* with size classes of 0.33-1mm, 1-2mm and 2-5mm showed relatively high abundances in the southern part, whereas the plankton >5mm peaked in the southern and northernmost stations of the study area. Log-transformed abundances of the plankton (0.33-1mm, 1-2mm and 2-5mm) showed significant correlation with environmental factors and 16 neustonic zooplankton taxa (330μm-1mm), especially salinity (p<0.05) and fish larvae (p<0.01). Except plankton >5mm, *S. fusiformis* of the other 3 size classes was negatively correlated with salinity, indicating that the high abundances were existing in the less saline waters. On the other hand, the plankton in the range of 5.75-88.50 mm (ave. 21.68mm) was likely associated directly with the currents rather than other environmental factors. And, *S. fusiformis* of all size classes was not significantly correlated with the most neustonic zooplankton groups except fish larvae, indicating that the widespread *S. fusiformis* did not affect most taxa in the near-surface zooplankton during the study. Our results suggest that *S. fusiformis* showed range expansion at seas around Korea associated with currents and salinity during the study considering the previous studies.

S01-17317 Poster

The ecological effects of the bloom forming giant jellyfish Nemopilema nomurai in China coastal sea

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Massive blooms of *Nemopilema nomurai* have occurred recently across East Asian waters. They are potentially important as zooplankton predators, as well as being competitors for prey with zooplanktivorous fish. We combined estimated the respiration rate, feeding rate, gut content, and Ecopath with Ecosim (EwE) to evaluate the ecological effects of N. nomurai. The predation effects on zooplankton by *N. nomurai in situ* were estimated through cruises. The gut contents in earlier stage of *N. nomurai* indicated that copepods were an important food source; copepods <1000 μm represented the bulk of total prey intake in number (> 99 %). A series of mass balanced models were conducted through Ecopath with Ecosim (EwE) based on the spring and summer surveys from 2012 to 2014. *N. nomurai* was dominant in combined fish-*N. nomurai* energy consumption rate, they consumed a larger proportion of the zooplankton production compared to pelagic fishes in both the two stages and served as a loss-pathway with minimal production of *N. nomurai* transferred to higher trophic levels. Scenario analyses revealed that fluctuations in population size of *N. nomurai* had a significant impact on other functional groups due to the direct or indirect competition for food resources. The investigation of the ecological effects of *N. nomurai* in this talk would provide valuable insights into the importance of N. nomurai within the food web of the China coastal sea.

S01-17396 Poster -> ORAL

Will Atlantification lead to a more gelatinous future of the European Arctic?

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Gelatinous zooplankton (GZ; pelagic cnidarians and ctenophores), are key players in marine ecosystems. Aside from their trophic importance, rapid reproductive cycles of GZ render their population size and structure tightly coupled to the environment, making them the ideal bioindicators for monitoring changes in the World's Ocean. Unfortunately, due to their delicate nature and convoluted taxonomy, data on their distribution are scarce and of poor taxonomic resolution. To tackle this paucity of data, here we re-analyzed zooplankton time series (2003-2014) run by the Institute of Oceanology (Polish Academy of Sciences), to investigate the future of GZ communities in the European Arctic under the scenario of progressing Atlantification. Specifically, we tested 1) whether oceanic fronts modulate the spreading of boreal GZ in the Arctic? and 2) how will the most abundant GZ in the region, *Aglantha digitale*, respond to ongoing changes? We found that the two fronts (Arctic and Polar), which flank the main inflow of the Atlantic waters to the Arctic, constitute a semi-permeable barrier for GZ distribution, maintaining distinct GZ community across fronts. Further, we found evidence, that year after year, *A. digitale* reproduced earlier in the Fram Strait, and in anomalously warm period (2005-2007) may have even reproduced twice per season. Overall, these findings may be interpreted as hinting towards more gelatinous future of the European Arctic.

Session 2: Interactions between zooplankton and pollution in a changing ocean

Convenors:
Penelope Lindeque (UK), corresponding
Rodrigo Almeda Garcia (Spain)
Matthew Cole (UK)
Amanda Dawson (Australia)
Claudia Halsband (Norway)
Sinja Rist (Denmark)

Invited Speakers:
Claudia Halsband (Akvaplan-Niva, Norway)

Zooplankton is exposed to a multitude of pollutants in marine environments, stemming from anthropogenic activities both at land and at sea. Such pollutants include microplastics and microfibres that are the predominant forms of plastic debris. Negative impacts on zooplankton from pollutants have been reported on many levels – from a molecular level to populations, threatening marine biodiversity and ecosystem functioning. However, our understanding of the effects of pollution on zooplankton considerably lags behind the continuous emergence of new contaminants, including novel plastics, tyre particles, plastic additives, pharmaceuticals, personal care products, endocrine disruptors, pesticides, and their transformation products. There is still ambiguity in the impact of pollutants on the breadth of zooplankton species and developmental stages, a paucity of evidence on how pollutants can impact upon higher levels of biological organisation (i.e. individuals, populations, communities, ecosystem structure and function) and additionally, a lack of understanding on the role of zooplankton in the fate of pollutants in marine environments. Furthermore, knowledge on the impacts of pollution in a changing climate with multiple anthropogenic stressors is limited.

S02-17397 Invited

Heavy metals, organic chemicals, microplastics - how sensitive is zooplankton to pollution?

Claudia **Halsband**

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Marine zooplankton encounter pollution from a multitude of land- and sea-based human activities through agricultural runoff, wastewater inputs, and industrial emissions. In addition, long-range transported airborne pollutants eventually enter the oceans through rainfall or dust fallout, and reach otherwise untouched remote areas, such as islands and the polar regions. The toxicity of chemical pollutants, including heavy metals, petrochemicals and pesticides, to zooplankton has been studied since the 1970s, and persistent organic pollutants (POPs), PFAS, and nanomaterials have since been added to the body of scientific literature. Recently, investigations of microplastics and microfibers add a layer of complexity, where both the physical traits of the particle and the chemical traits of leachable additives or adsorbed hydrophobic chemicals may drive the toxicity of these particulate contaminants. Here, I review examples of zooplankton-pollutant interactions for microplastics, car tire additives, and heavy metals studied with different approaches ranging from laboratory experiments, field sampling in combination with modeling efforts, to theoretical trait-based approaches. The individual phenotypic variability and species-specific patterns of sensitivity or resilience that emerge call for autecological assessments of vulnerability to pollution against the backdrop of changes in ocean climate, such as warming and ocean acidification. The multitude of pressures acting simultaneously demonstrates the urgent need to take multi-stress conditions and cocktail effects into account to understand and predict the anthropogenic impacts on marine zooplankton.

S02-17059 Oral (ECOP)

A comparison of the toxicity of biodegradable microfibres from textiles and cigarette butts

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Microplastics in the marine environment have emerged as a complex and concerning issue in recent years. Microfibres are the most abundant form of microplastic found in the marine environment and are bioavailable to a wide range of marine animals, including zooplankton. Microfibres are produced from textiles and clothing through wear or washing, and cellulose acetate fibres are produced during the breakdown of cigarette butts. Bio-based, biodegradable polymers are widely considered to be a viable alternative to traditional plastic, but little is known about their ecotoxicological risk. This study sought to explore and compare the toxicity of microfibres from a) biodegradable and conventional plastic textiles in both dyed and undyed forms and b) cigarette butts from smoked, unsmoked and weathered cigarettes, on the widely distributed copepod, *Acartia tonsa*. Adapting existing ISO toxicity standards, partial life cycle assessments of female F_0 and resulting F_1 generations were conducted, using microfibres sized 63—125 µm at a concentration of 0.1 mg L^{-1}. Dyed forms of textiles were no more toxic than undyed forms and whilst some differences were evident between materials, there were no clear trends to indicate that, at near term future scenarios, fibres from biodegradable materials pose any greater or lesser risk than traditional anthropogenic fibres to copepod reproductive success. However, at higher concentrations, toxicity is readily evident and therefore we cannot switch to biodegradable polymers and carry on as a business as usual, continuing to create the same volume of waste that leaches into the environment.

S02-17075 Oral

Partial life-cycle toxicity test for anthropogenic particles using *Acartia tonsa*

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Anthropogenic particles, comprising microplastics, tyre particles and paint particles, are a prolific marine pollutant. To determine the risks posed by anthropogenic particles requires standardised toxicity tests that can be used to determine thresholds for lethal and sub-lethal effects in representative biota. A plethora of toxicity tests are available for waterborne chemicals, but these protocols are often inappropriate for testing anthropogenic particulates given their physio-chemical properties. In this study we develop and optimise a standardised partial life-cycle toxicity test for anthropogenic particles using the globally-distributed, coastal and estuarine copepod *Acartia tonsa*. Trial exposures used 0, 0.01, 0.1, 1 and 10 µg/mL of a tripolymer microplastic blend comprising cryoground polyethylene, polypropylene and nylon particles (5-100 µm). Adult female copepods were incubated with microplastics for 5 days and subsequently used in a 24-hour feeding and egg production experiment, allowing for determination of adult mortality, feeding rate, egg production rate and egg size. Copepod eggs were then incubated until >50% of progeny had moulted into copepodite stage; preserved samples were subsequently used to calculate hatching success, juvenile mortality, larval development ratio and copepodite size. Here we present our protocols alongside lethal and sub-lethal (feeding, fecundity, development, growth) dose concentrations for the test microplastics. The test provides a standardised method for establishing comparative toxicity of anthropogenic particles, with the focus on apical endpoints (survival, growth, reproduction) being of high relevance to ecosystem health.

S02-17083 Oral

Bioavailability and ingestion of microplastic by zooplankton in the natural environment

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Microplastics have been documented in marine environments worldwide where they pose a potential risk to biota. Zooplankton may be particular susceptible, as the microplastics overlap with the size range of their natural prey and can therefore be readily ingested. Laboratory studies have established that zooplankton, such as copepods, can consume microplastics, affecting their energy budget and negatively impacting upon reproduction, health and survival. As such, understanding the extent to which zooplankton encounter and ingest plastic particles and fibres within their natural environment is imperative, not least to reliably assess the risk that different microplastics pose to animals near the base of the marine food web.

In this study, we sampled six sites in the western English Channel (United Kingdom) over the course of one year to determine the types and amount of anthropogenic debris available to and ingested by zooplankton in the natural environment. Over 12,000 zooplankton were processed, with ingested and waterborne microplastics characterised and counted. Our results demonstrate that zooplankton routinely encounter and ingest microplastics under natural conditions. We will present the encounter rate and incidence of ingestion over spatial and temporal scales, with a comparison between two zooplankton groups, copepods and decapods. The drivers of ingestion and selectivity will be discussed.

S02-17090 Oral (ECOP)

Representing zooplankton grazing of microplastics in models

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Observed negative effects from microplastic ingestion by zooplankton indicate a role for numerical models to assess their wider implications. However, how to parameterise this ingestion remains enigmatic. Many ecological models applied at global scale use zooplankton terms as ‘closure terms’ to fit nutrient distributions, primary and export production rates to observations. Thus biogeochemistry in these models are very sensitive to even small changes to zooplankton grazing or mortality. Furthermore, the widely applied Holling type II grazing formulation that includes multiple prey choices and unique grazing preferences is not fit for purpose and should not be used to simulate novel or variable food sources. Lastly, it remains unclear how to generalize microplastics traits for simple NPZD models. In this presentation I will summarise the major challenges facing the incorporation of microplastic ingestion into global scale numerical models and outline how progress might be made on this topic.

S02-17097 Oral (upd Feb 7)

Microplastics in zooplankton from the tropical estuarine fronts of Kuala Terengganu, Malaysia, during the southwest monsoon

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Estuaries are the main route by which plastic enters the ocean from land, and it is plausible that they can retain and redistribute microplastics. However, the role of estuarine fronts in plastic pollution and their interaction with organisms remains unclear. In this study, we investigated the potential of microplastic uptake in zooplankton from the tropical estuarine areas of Kuala Terengganu. Samples were collected from three main regions of the estuary; plume, front and shelf waters, in May and August 2022. In the frontal zone, especially in the middle layer of the estuary, the density of zooplankton is higher during high tide, with the copepod group showing higher abundance in both sampling events (> 80%). Microplastics in zooplankton were detected in greater abundance in the frontal region, particularly in surface water, during high tide than in the plume and shelf regions. Two types of microplastics were recorded at all stations: fragments (98%) and pellets (2%). The size of the recorded fragments and pellets was 29.7±13.85 µm and 18 µm, respectively, with a larger size spectrum observed in the frontal region than in the plume and shelf regions. The ingested microplastic was recorded only from copepods and gastropods, and the range of ingested microplastic was 0.008 and 0.036 particles ind^{-1}, respectively. Through this study, the results obtained here provide baseline information for the microplastic uptake in the estuarine region, which is sought as a microplastic transport system between the river and the open sea.

S02-17129 Oral (ECOP)

Copepods as microplastic reservoirs in the marine environment: A fusion of field experiments and systematic review analysis

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Copepods are the most abundant metazoans in the oceans, linking lower to higher trophic levels and playing a key role in carbon cycling and climate regulation processes. However, their interaction with microplastics (MP) in field conditions is still poorly studied, and data are lacking for hyponeustonic taxa. This study aims to evaluate whether marine copepods could represent an extended temporary reservoir of MP within the oceans, integrating systematic review analysis and field experiments.

We assessed the ingestion of MP in 2793 Pontellid copepods (*Pontella mediterranea*), the primary components of the hyponeustonic assemblage. We observed abundances of *P. mediterranea* ranging from 41.67 to 1174.83 ind/m^3 and low MP ingestion values (0.11 ± 0.05 MP/ind). However, given its abundance, this species could retain an average of 45.15 and a maximum, during a bloom, of 220 MP per m^3 of seawater. Preliminary results of the systematic review confirm that, in field conditions, the ingestion of MPs by copepods occurs at low frequencies, associated with low mean values, as found in *P. mediterranea*, with low variability between species and families, and water layers. However, when MP ingestion is analyzed in relation to copepod density (MP/m^3), this taxon could represent one of the largest marine reservoirs of MP.

The ingestion and egestion of MPs by copepods could potentially affect the vertical distribution of MPs, influencing their availability and impacting the global carbon cycle and climate regulation. More studies are needed to assess the global-scale effects of MP ingestion by copepods.

Keywords: neuston, copepods, microplastic, marine pollution, Pontellidae

S02-17191 Oral (ECOP)

Zooplankton ecological baselines in the Eastern Tropical Pacific amidst deep-sea mining risks

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Midwater zooplankton assemblages in the Eastern Tropical Pacific (ETP) are highly structured across water column oxygen gradients, and exhibit spatial variability linked to large-scale ocean currents and equatorial upwelling. The emerging industry of deep-sea polymetallic nodule mining in this region is likely to introduce new risks related to release of sediment plumes in midwater. We characterized the spatial and temporal variability of zooplankton biomass, diversity, and community structure across midwater depths (0-1500m) in the eastern Clarion Clipperton Zone (CCZ), an area with a pronounced oxygen minimum zone (OMZ) that fluctuates seasonally, to establish ecological baselines for the CCZ prior to mining impacts. Zooplankton were collected by 1m² MOCNESS tows during two cruises (Spring, Fall) at two sites: a preservation reference zone and a test mining area, both within the NORI-D exploration mining license. Zooplankton biomass was higher in spring, coinciding with enhanced primary productivity, increased passive particle flux and less hypoxic conditions, with seasonal changes most pronounced in the upper oxycline and OMZ. Spatial differences in biomass and community composition were also observed between sites, providing insight into the utility of the preservation reference zone for impact monitoring. Multigene metabarcoding (18S, COI) and image-based ZooScan analyses of preserved samples were used to assess diversity and community structure, with analyses ongoing to characterize assemblages at highest risk of potential impact in the upper bathypelagic. Results will be discussed in the context of establishing effective ecological baselines for assessing deep-sea mining impacts in midwater.

S02-17193 Oral

Crude oil induces metamorphosis in marine invertebrate planktonic larvae.

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Metamorphosis is a critical process in the life cycle of most marine benthic invertebrates, determining their transition from plankton to benthos. It affects dispersal and settlement, and therefore decisively influences the dynamics of marine invertebrate populations. An extended period of metamorphic competence is an adaptive feature of numerous invertebrate species that increases the likelihood of finding a habitat suitable for settlement and survival. We found that crude oil and residues of burnt oil rapidly induce metamorphosis in two different marine invertebrate larvae, previously unknown sublethal effects of oil pollution. When exposed to environmentally realistic oil concentrations, up to 84% of tested echinoderm larvae responded by undergoing metamorphosis. Similarly, up to 87% of gastropod larvae metamorphosed in response to burnt oil residues. This study demonstrates that crude oil and its burned residues can act as metamorphic inducers in marine planktonic larvae, short-circuiting adaptive metamorphic delay. Future studies on molecular pathways and oil-bacteria-metamorphosis interactions are needed to fully understand the direct or indirect mechanisms of oil-induced metamorphosis in marine invertebrates. With 90% of chronic oiling occurring in coastal areas, this previously undescribed impact of crude oil on planktonic larvae may have global implications for marine invertebrate populations and biodiversity.

S02-17201 Oral (ECOP)

Estimation of *in-situ* concentrations of microplastics smaller than 300 µm using gut contests of pelagic tunicate: *Salpa fusiformis*

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The ubiquitous presence of microplastics (MPs) has emerged as a significant threat to marine ecosystems. In particular, its characteristic of fragmentation is a serious problem for the planktonic food web as it would produce numberless inert non-living particles, which fall within the range of prey organisms of zooplankton. However, information on the distributions of ocean MPs smaller than 300 µm, which cannot be collected by a plankton (neuston) net is considerably limited due to the lack of conventional methods of quantification. In this study, we examined the applicability of utilizing salps, non-selective filter feeders, which ingest particles around 1 µm−1 mm with the highest filtration rates among the marine zooplanktons. As a model species, *Salpa fusiformis* collected from the Seto Island Sea and the Japan Sea, Japan used for the analysis. Their guts were dissolved with H_2O_2 and multi-enzyme detergent, and filtered on inorganic membrane filters to analyze MPs using µFT-IR. The result shows that 83.3% of *S. fusiformis* (n = 24) had MPs in their guts; the mean count per individual was 1.96±1.49 MPs with a size range from 23−789 µm. The number of MPs in the gut of *S. fusiformis* was then converted to the *in-situ* density by using previously published clearance rates and gut evacuation rates. Estimated *in-situ* density, 361−2,086 pieces/m^3 was within the range of those analyzed with the conventional method, suggesting that salps could be utilized as a biological sampler to monitor the small MPs.

S02-17207 Oral (ECOP)

How do chemical pollution and marine heatwaves affect planktonic abalone larvae?

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Survival and fitness of meroplanktonic larvae determine population dynamics of benthic invertebrates. With increasing anthropogenic stressors affecting the world’s oceans, it is crucial to understand how combined pressures can affect these sensitive early life stages. Here, we investigated the impacts of different types of chemical pollution in combination with a simulated marine heatwave on early and late larval stages of the abalone *Haliotis tuberculate coccinea*. Larvae were exposed to a range of concentrations of crude oil, leachates of car tire particles, or leachates of beached microplastics for two days. Exposure experiments were performed with larvae that were less than one day old as well as with competent larvae three days after fertilization. In early larvae, we analyzed effects on development and survival, while potential effects on metamorphosis were studied in late larvae. Early larvae were sensitive to all tested pollutants as shown by increased mortality. However, leachates of car tire particles induced the strongest effects as all surviving larvae showed signs of abnormal development. This effect was far less evident in the other pollutant treatments. The heatwave treatment had a significant negative effect on survival and markedly reduced metamorphosis in late larvae. In contrast, this process was only slightly affected by pollution, though in different directions (indicating reduced as well as enhanced metamorphosis). The results indicate different sensitivities of larvae depending on their age and the combination of stressors.

S02-17210 Oral (ECOP)

Toxicity assessment of contaminants of emerging concern (CECs) on marine zooplankton

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Zooplankton play pivotal roles in marine food webs and ecosystem functioning, and therefore, understanding the potential impacts of CECs on zooplankton is crucial for environmental risk assessment. In this study, we assess the toxicity of five CECs widely used as industrial additives and precursors on zooplankton. Specifically, the acute toxicity of benzotriazole, 4-tert octyl phenol, 1,3-diphenyl guanidine, benzyl alcohol, and caprolactam on the cosmopolitan planktonic copepod *Acartia tonsa* and the meroplanktonic stages of the keystone sea urchin *Arbacia lixula* was investigated. We determined the effects of 48-hour exposure to pollutant concentrations ranging from 0.001 to 1000 mg L^{-1} on copepod mortality and larval growth. All the studied CECs caused negative effects on zooplankton, but their toxicities varied notably among the compounds and model species/stages. Among the studied CECs, 4-tert octylphenol emerged as the most toxic compound to zooplankton, with a median effective concentration (EC_{50}) of 0.59 µg L^{-1} for *A. lixula* embryos. Benzotriazole and caprolactam exhibited comparatively lower toxicities with EC_{50} values of approx. 23 mg L^{-1} for both compounds for sea urchin embryos and 122 and 526 mg L^{-1}, respectively, for copepods. With plastic pollution in the aquatic systems projected to triple in the next decades, this research underscores the importance of assessing the potential harm posed by plastic additives on ecologically relevant zooplankton groups and calls for more research and mitigation actions on these types of pollutants.

S02-17215 Oral (ECOP) (p->o)

Climate change driven copper genotoxicity in two key Arctic zooplankton species

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The Arctic marine environment is experiencing unpreceded rates of changes due to global warming. Warming Arctic environments cause permafrost thawing and remobilisation of copper into marine environments. Calanoid copepods are an important energy source for higher trophic levels and key drivers for Arctic ecosystem functioning and food web dynamics. Acute multistressor experiments with copper under varying thermal regimes were conducted with *Calanus* spp. and *Acartia longiremis* collected from the Norwegian Arctic. Genetic integrity was measured by the fast micromethod assay and DNA damage was significantly elevated in *Calanus* spp. after 24 hours exposure for all treatments (0.07 ± 0.01 SSF (+3°C), 0.06 ± 0.01 SFF (Cu), 0.05 ± 0.01 SFF (Cu + 3°C), mean ± s.e.). A combination of Cu and + 3°C resulted in higher DNA damage after 4 and 8 hours compared with the Cu treatment alone. DNA damage was no longer detected after 24 hours of recovery in clean water. No Cu-induced DNA damage was detected in the Arctic-specialist *A. longiremis*, indicating higher resilience to this genotoxic stressor. Temperature induced DNA damage was detected in *A. longiremis* after 8 and 24 hours (0.05 ± 0.02 SFF, 0.02 ± 0.03 SFF, respectively). The toxicity mechanism driving the genotoxic response is still unknown, and gene expression analyses will target biomarkers for oxidative stress (e.g., *cat*, *ferritin*) and induction of DNA repair (e.g., *ercc1*, *parp1*). Metal contamination and ocean warming can trigger genetic damage and wider implications on future copepod populations and food web dynamics should be investigated further.

S02-17217 Oral (ECOP)

Searching for environmentally safer plastic additives using zooplankton as bioindicators

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Thousands of chemicals, commonly known as "plastic additives" are intentionally added during the manufacturing of plastics to enhance their properties. For most of these plastic additives, we lack a proper toxicity characterization. Millions of tons of plastic litter enter the ocean every year and, since their additives can leach into the aquatic environment, the potential impacts of plastic additives on marine ecosystems are an issue of high environmental concern. In this study, we compared the acute toxicity of five types of conventional functional additives with potentially safer replacements using zooplankton as test models (sea urchin embryos - *Arbacia lixula* - and the copepod *Acartia tonsa*). Specifically, we determined the toxicity of DEHP (plasticizer) BPA (plasticizer), TBBPA (brominated flame retardants), BP-3 (UV filter), and PFOA (nonstick coating) with their respective proposed alternatives, ATEC, BPS, TCEP, BP-5, and PFBA. We found that some of the proposed alternative additives had lower toxicity than the conventional additive to the studied species. For example, BPS had a median effective concentration (EC_{50}) >100 mg L^{-1} while BPA had an EC_{50}=0.16 mg L^{-1} in sea urchin embryos. Similarly, PFBA had an EC_{50} >100 mg L^{-1} compared to PFOA which had an EC_{50}=20 mg L^{-1} for copepods. The specific case of ATEC was found to be even more toxic than the conventional additive DEHP for the studied species. This study helps to provide solid scientific grounds for the choice of environmentally safer plastic additives, a critical need to reduce the impact of plastic pollution on marine ecosystems.

Keyword: Plastic additives, toxicity, safer alternatives, planktonic larvae, copepods

S02-17220 Oral (ECOP)

Impact of produced water on the survival of planktonic copepods under climate change

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Produced water (PW) is a subproduct of oil extraction that is discharged into the sea, being the largest source of offshore marine oil pollution. Approximately 300 million cubic meters of PW are released into the North Sea annually. Produced water consists of a wide range of pollutants, including crude oil, polycyclic aromatic hydrocarbons (PAHs), alkylphenols (AP), heavy metals, and radioactive materials (NORM). Copepods constitute up to 80% of the mesozooplankton biomass in the oceans and are an important link between the base of marine food webs and higher trophic levels, contributing to nutrient recycling and carbon sequestration. In this study, the three main orders of marine copepods were investigated: calanoids (*Centropages hamatus*), cyclopoids (*Oithona davisae*) and harpacticoids (*Amonardia normanni*). Copepods were exposed to dilutions between 0.5% and 10% of PW for a period of 72 hours, at two temperatures: 18°C (average North Sea temperature) and 22°C (estimated SSP 5-8.5 temperature in the North Sea), and effects on the survival were measured. Our preliminary results show strong effects on survival of exposed copepods, even at low PW concentrations (<5%), with a significant effect under climate change conditions. In turn, copepods showed different sensitivities to contaminants depending on the species. Chemical analysis of the PW showed a relatively high concentration of crude oil (mg/L range), and PAHs (µg/L range) among other contaminants. This study emphasizes the need for further research on the ecological risks associated with the discharge of PW in marine plankton.

S02-17230 Oral (ECOP)

Behavioral responses of marine pelagic copepods to microplastics

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The ubiquity and persistence of microplastics (MPs) in the ocean have raised concerns about the impacts of this pollutant on zooplankton. Pelagic copepods are key components of marine ecosystems and a major link between low and high trophic levels in the marine food web. Although the ingestion of microplastics in zooplankton has been observed in field surveys and laboratory studies, there is still not a clear understanding of the mechanisms related to this behavior. Here, we present an overview of several behavioral studies based on direct small-scale video observations of copepods exposed to different sizes and types of MPs. Our results show feeding current copepods can discriminate and reject microplastics even at high exposure concentrations. Our observations demonstrate that copepods effectively distinguish between proper food (algae) and microplastics; however, there is a size threshold for chemical discrimination of MPs by copepods. The rejection rate was up to 90% when the MPs were >20 um but decreased to 40% when the MPs were 8 um. No behavioral response was observed when the microplastics were 4 um. These results indicate that the risk of MP ingestion is lower than expected since copepods can reject MPs that overlap with their prey size spectra, but raises concerns about the small MP fractions and nanoplastics that can be passively ingested by copepods. These findings emphasize the relevance of behavioral observations to better understand the potential risk of MPs entering and being transferred into marine food webs.

S02-17263 Oral

Genetic toxicology of zooplankton in a changing marine environment

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Understanding organism responses to pollutants and environment stressors is important in light of climate change shifting regimes of temperature, pH, and spread of contaminants at rates previously not experienced in stable marine environments. Organisms elicit responses in the form of detoxification, stress response mechanisms, and damage repair processes. Impacts and damage at the genetic level can underpin higher-level effects in physiology, behaviour, survival, and transgenerational impacts, which can drive population and species level changes. Species can vary in their sensitivity to genetic stress as well as their capacity to respond and adapt. Comparative experiments with *Acartia longiremis* and *Calanus* spp. provide insight into sensitivity and resilience of Arctic zooplankton populations. Water conditions simulating predicted Arctic ocean acidification cause genotoxicological impacts in *A. longiremis* in the form of DNA strand breaks, with indications that older life stages are more susceptible to genotoxic impacts compared with individuals collected from earlier in the summer season. Genetic damage was also detected in *Calanus* spp. exposed to multistressor conditions of ocean acidification and warming, and *A. longiremis* exposed to combined temperature and copper conditions, and *A. longiremis* is more resilient to DNA damage compared with *Calanus* spp. Ongoing gene expression analyses will investigate the comparative capacity for DNA repair between the two species, and develop tools for transcriptional biomarkers of oxidative stress to determine the molecular mechanisms driving adverse effects and mortality. Arctic genetic ecotoxicology of zooplankton can inform on wider ecosystem vulnerability to future climate and pollution conditions.

S02-17266 Oral

Jellyfish as bioindicators: exploring microplastic contamination in *Blackfordia virginica* and its surrounding environment

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Microplastic pollution poses a major threat to aquatic environments, being essential to find new suitable bioindicators of microplastics entering the food webs. Jellyfish are considered potential good bioindicators, as they often exhibit high abundances, are easy to collect and already monitored, and their spatio-temporal dynamics may reflect the distribution of floating plastic debris. But until now only few studies were performed with these organisms to verify their suitability as bioindicators of microplastics pollution. Thus, the aim of this study is to determine the presence of microplastics inside the guts of the hydrozoa *Blackfordia virginica* and if they are representative of what is found in the surrounding water. In 2021, monthly horizontal mesozooplankton hauls (200 µm size) were conducted in the middle estuary of Guadiana River to obtain *B. virginica*, and vertical hauls (100 µm size) to address water contamination. Jellyfish will be subjected to a potassium hydroxide digestion (10% KOH), and the water to a hydrogen peroxide digestion (30% H_2O_2). All microplastics will be analysed in terms of size, colour and type, and the polymer detection by micro-Fourier Transform Infrared Spectroscopy (micro-FTIR). Outcome results will provide the first quantification of microplastics ingestion by *B. virginica* in the Guadiana River estuary, a highly important ecosystem that act as a nursery area and provide food resources and habitat for numerous organisms. Also, it will give information on whether these organisms can be used as potential bioindicators of microplastics.

S02-17294 Oral -> RECORDED

Microplastics in crab larvae on the US mid-Atlantic shelf and a laboratory investigation on their growth and physiology

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We will highlight results from two complementary studies on microplastic interactions with larval crabs. First, we discuss a field campaign studying the distribution of microplastics and larval/post-larval blue crabs *Callinectes sapidus* at the mouth of Delaware Bay (USA) and inner Atlantic shelf. We did not find evidence of co-localized aggregation in our samples. We digested zoea larvae from these samples and found 2 microplastic pieces per individual on average. Semi-synthetic rayon was common, as were plastic polymers polytetrafluoroethylene, nylon, polyethylene and polypropylene. Fragments and fibers were the only plastic shapes observed, with fragments 3-fold more common in larvae. Size of extracted microplastics ranged from 12 to 872 µm, with a mean of 105 µm. In a related study, we reared mud crab *Panopeus herbstii* zoea larvae (z1-z4) and megalopae with microfibers (50 µm length, PETE) for (i) full exposure (z1-megalopae), (ii) early exposure (z1-z3), and (iii) late exposure (z3-megalopae) at concentrations of 0, 0.1, 1, and 10 microfibers/mL. Survivorship was unaffected by treatment, but as microfiber concentration increased, (1) body size decreased, and (2) stage duration increased. Body size effects were observed while plastic was present in cultures and disappeared upon the subsequent molt once plastic was removed, while prolonged stage duration remained at high concentration after removal. Results are consistent with microplastic exposure affecting larval energy budgets, yet larval ingestion of microfibers themselves was negligible. We show through a final experiment with microplastics and sand particles that increased energy expenditure for particle selection/avoidance could explain the earlier results.

S02-17299 Oral (ECOP)

A mesocosm approach to evaluate the effects of microplastics from conventional plastics and bioplastics on the zooplankton community

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Microplastics (MPs) are pollutants of global concern due to their persistence and accumulation in aquatic ecosystems. Increasing plastic pollution, among other factors, has promoted the search for alternative materials like bio-based polymers and biodegradable plastics (“bioplastics”). However, little is known about the impacts of MPs from conventional plastics and bioplastics on zooplankton communities after long-term exposure. We conducted two long-term mesocosm (2 m^3) experiments mimicking environmental conditions to investigate the effects of MPs from (i) weathered conventional plastics and (ii) commercial biopolymers on the Baltic Sea zooplankton community. In the first study, five weeks of exposure to MPs from micronized weathered materials polyvinyl chloride (PVC), polypropylene (PP), polystyrene (PS), and nylon (PA) did not significantly affect the structure and dynamics of the zooplankton community. However, in the second study, we found that exposure to MPs from commercial biopolymers (polylactic acid (PLA), and poly (hydroxybutyrate-co-hydroxyvalerate) (PHBv)) significantly decreased the abundance of zooplankton. PHBv was the most toxic polymer, causing a reduction in zooplankton abundance by half after 2-3 weeks of exposure. Our findings indicate that weathered MPs from conventional plastics have a minor/negligible impact on zooplankton communities at environmentally relevant concentrations and that the adverse effects of plastics are related to additive leachates. The higher toxicity of commercial biopolymers compared to conventional plastics to plankton communities raises concerns about the chemical safety of commercial bioplastics and calls for more research on the toxicity of functional additives associated with bioplastics to find proper environmentally safer replacements for conventional plastics.

S02-17333 Oral

Impact of plastic additive leachates on zooplankton.

Rodrigo **Almeda**[1], Jessy Le Du-Carrée[1], Sinja Rist[1,2], Gunaalan Kuddithamby[2], Olalla Alonso-Lopez[1], Anna Cunill[1], Antonio Paule[1], Marta Sampalo[1], Chiara Intermite[1], Evanthia Bournaka[2]; Wilma Moreira[1], Luis Chomienne[1], Ico Martinez[1], Alicia Herrera[1], Torkel G. Nielsen[2], and May Gomez[1]

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Millions of tons of plastic enter the ocean every year and plastic pollution is projected to triple in the next two decades. Besides their main synthetic polymers, plastics are also comprised of additives incorporated during their manufacture to give them specific properties. When plastics enter the ocean, many of these additives can leach and potentially affect zooplankton communities. Here, we present a summary of the main results from a Spanish National Research Project (MICROPLEACH) on the effects of leachates from different plastic materials on key zooplankton groups. We found that leachates from micronized conventional plastics generally have a low toxicity to zooplankton, particularly after weathering. However, leachates from the tested commercial biopolymers, biodegradable plastics, and cigarette butts show higher toxicity than from conventional plastics to zooplankton. Leachates from tire wear particles and micronized crumb rubber were the most toxic to zooplankton, with harmful effects at environmentally relevant concentrations. Tire wear particles are considered one of the major sources of microplastic pollution in the environment, and based on this study and others, are also one of the most dangerous types of microplastics to marine ecosystems given their additives. Our results indicate that the toxicity of MPs on zooplankton is directly related to their functional additives that leach into the water. The focus only on microplastic as particles or polymer types is not sufficient to understand the potential effects of plastic pollution on marine food webs. More research is needed to evaluate the ecological effects of plastic additives and their transformation products and to find environmentally safer additives to reduce the impact of plastic pollution in the ocean.

S02-17346 Oral

Microplastics in copepods from Jiaozhou Bay, the Yellow Sea

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The characteristics of microplastics (MPs) in copepods, the seasonal changes of MPs ingested by copepods and the environmental factors that affect the ingestion of MPs by copepods were studied in Jiaozhou Bay. The results revealed a significant seasonal difference in MP per copepod in Jiaozhou Bay, which were 0.26, 0.23, 0.14 and 0.16 in February, May, August and November, respectively. The MP per copepod was significantly higher in winter and spring than in summer and significantly higher in the estuarine zone than in other zones. Seawater temperature was negatively correlated with the MP per copepod. No significant seasonal differences were detected in the characteristics of MPs in copepods in Jiaozhou Bay. The size of MPs in copepods ranged from 90 to 2485 µm, with an average of 454 ± 376 µm. Fibrous MPs were the most risky to copepods, accounting for 92% of the total ingested MPs. In terms of the chemical composition of the MPs, a total of 11 polymers were detected in copepods in Jiaozhou Bay in the four seasons. The main components were polyester and cellophane, accounting for 41.9% and 25.7%, respectively. The results provide the key parameters of the MPs in copepods in Jiaozhou Bay and is an important basis for further ecological risk assessments of MPs on key marine zooplankton.

S02-17259 Poster (ECOP) CANCELLED

~~Exploring the toxicity of cigarette butts on marine zooplankton ¿Are the most toxic waste that can be found on the coast?~~

~~Olalla **Alonso-López**[1], Sinja Rist[2], Rodrigo Almeda[1]~~

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~~Cigarette butts (CBs) are one of the most common types of litter on urban beaches and usually is considered a biodegradable material underestimating the risk that it has to the environment. The effects of CBs on mammals have been deeply studied in the last few years, however, little is known about the effect of these residues on marine zooplankton. The main aim of our study is to contribute to the dataset of toxicity hazards produced by the leachates of CBs and compare these results with other types of residues that can appear in the marine environment. An experimental battery of marine plankton bioassays including model species such as *Acartia tonsa* nauplii or *Paracentrotus lividus* larvae were used for this study. Results showed that the toxicity of CBs in this species far exceeds the toxicity of other kinds of debris. Encouraging new waste management policies and putting the spotlight on the risk of CBs on a critical part of the marine food web are the expectations of this work.~~

S02-17365 Poster

Lethal effect of fibrous microplastic on coastal copepod, *Acartia erythraea*

Kazutaka **Takahashi**[1], Jun Chin Teh [2]

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Microplastics (plastic particles or fibres < 5 mm in size) have been accumulating in the oceans over the past few decades and a number of studies have shown that microplastics are ingested by various zooplankton, resulting in reduced feeding, energetic deficiencies, injury, and death. Fibrous microplastic released from textiles is a dominant component transported by rivers to coastal zones, while only a limited number of studies examined its effect on zooplankton production. In this study, we investigated the impact of fibrous microplastic exposure on survival in a coastal planktonic copepod *Acartia*, which forms dense aggregation near the bottom during daytime. The experiments were conducted with *A. erythraea* collected from Tainoura, Shin-Kamigoto, Kyushu. Five females were incubated in 10-mL chamber with 1 piece of polyethene fibre (ca 1 mm long) for 24 h in dark conditions. Each of the 22 replicates was prepared for fed (*Thalassiosira weissflogii*) and non-fed treatments. The experiments revealed that 5 % of *A. erythraea* in the non-fed treatment hold a piece of fibre in their mouths, while no such phenomenon was observed in the fed treatments, suggesting that copepods accidentally ingest the fibre due to hanger response. All copepods that had the fibre in their mouths eventually died as they could not feed due to the fibre penetrating deep into the gut. The finding implies that a single piece of microplastic fibre remaining at the bottom of coastal zones could continuously kill copepods aggregating near the bottom due to its non-degradability.

S02-17719 Poster (ECOP)

Cumulative impacts of oil pollution and climate change on Arctic copepods

Sinja **Rist**[1], Sofie Rask[1], Iliana V. Ntinou[2], Øystein Varpe[2], Martin Lindegren[1], Kevin Ugwu[3], Maria Larsson[3], Viktor Sjöberg[3] and Torkel G. Nielsen[1]

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Arctic biota are exposed to multiple stressors, among these climate change and pollution. These are expected to increase in the Arctic in the future. Still, their combined impact on the marine ecosystem is not well understood. In this study, we investigated the cumulative impact of crude oil, warming and freshening on the feeding of the copepod species *Calanus glacialis* and *Calanus finmarchicus* in Western Greenland. Adult females were exposed to ambient conditions (0°C + 33 psu) and two scenarios of climate change: 5°C + 27 psu (Scenario 1), 5°C + 20 psu (Scenario 2). All three conditions were tested in the absence and presence of mechanically dispersed crude oil (1 µL L^{-1}). During the six days of exposure, incubations were renewed daily and the number of fecal pellets was counted. The fecal pellet volume was measured three times. Warming from 0 to 5°C plus freshening from 33 to 27 psu resulted in a significant increase in feeding for both species. However, when salinity dropped to 20 psu (at 5°C) feeding decreased for *C. glacialis,* while it fluctuated for *C. finmarchicus*. For both species, oil had the strongest effect, leading to a 68-83% reduction in feeding. This overshadowed any differences between climatic conditions. All three stressors had significant single effects and several joint effects on feeding. The results demonstrate the sensitivity of Arctic copepods to environmentally realistic concentrations of crude oil and climate change.

Session 3: The role of zooplankton in the Biological Carbon Pump

Convenors:
Svenja Halfter (New Zealand), corresponding
Katy Baker (Australia)
Klas Ove Moeller (Germany)
Deborah Steinberg (USA)

Invited Speakers:
Moira Decima
(University of California, San Diego, USA)

Zooplankton play an important role in the transport of carbon from the surface ocean to the deep sea, also called the Biological Carbon Pump (BCP). Zooplankton contribute to the passive carbon flux by ingesting and modifying sinking particles, or by producing fast-sinking faecal pellets and carcasses. In addition, through their daily and seasonal migrations, zooplankton actively inject particulate and dissolved carbon into the ocean's interior, away from the atmosphere. Consequently, they contribute to climate regulation and to nutrient recycling in the water column.

Changes in zooplankton community composition, physiology, and behaviour in response to environmental conditions have a significant effect on BCP efficiency. Yet, calculating carbon budgets has proven difficult due to insufficient parameterisation of water column processes, such as carbon recycling and export/sequestration. Knowledge gaps remain, including uncertainties in global zooplankton biomass estimates, physiological rates, zooplankton-mediated processes in the mesopelagic zone, and responses of the zooplankton-focused BCP to climate change.

As part of the Joint Exploration of the Twilight Zone Ocean Network (JETZON), we invite presentations on the way zooplankton shape the passive and active carbon flux. Presentations can include observational, experimental, and modelling studies on a broad range of zooplankton taxa, in particular tunicates and fish larvae, and their impact on the BCP. We especially encourage talks on the use of new technologies, e.g., gliders or floats, that can be integrated with traditional methods to close knowledge gaps in zooplankton-mediated carbon flux.

S03-17279 Invited

Salps vs. crustaceans: comparing their contribution to carbon export pathways in the Southern Ocean Subtropical Front region

Moira **Décima**, Mike Stukel, Andrés Gutiérrez-Rodríguez, Scott D. Nodder, Karl Safi, Morgan Meyers, Christian Fender, Thomas Kelly, Florian Lüskow, Alexis A. Bahl, Evgeny A. Pakhomov, and Matt Pinkerton

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Crustacean and gelatinous grazers can affect trophic and export pathways in very different ways. Crustacean zooplankton, such as copepods and krill, consume larger particles, produce fecal pellets that sink at rates of 10-100s m d^{-1}, and exhibit diel vertical migration (DVM) to varying depths depending on their size. Salps, on the contrary, are largely unselective grazers that can consume pico-sized cells and produce fast-sinking pellets that can quickly reach the seafloor (speed >1000 m d^{-1}). Salps also exhibit DVM to variable depths depending on species and size. In this study, we quantify the multiple pathways by which salps and crustaceans mediate carbon export during five Lagrangian experiments conducted during the austral spring 2018 within the Subtropical Front region, east of New Zealand. The study area is typically dominated by crustacean zooplankton, but there are frequent salp blooms, primarily in late spring and early summer. Studied locations included areas with and without salp blooms as well as both subtropical (warm, saline, low macronutrient) and subantarctic (cold, fresh, high macronutrient, iron-limited) conditions. Using i*n situ* measurements of depth-resolved biomass and grazing of both salp and crustacean zooplankton, we compare their respective contributions to POC flux measured using Particle Interceptor Traps (PITs) and estimate any additional contribution to flux via mortality (estimated using Bayesian statistical modeling techniques) and respiration at various depths. We discuss the implications for flux patterns in this globally important region at the northern extent of the Southern Ocean.

S03-17036 Oral (ECOP)

Influence of ocean alkalinity enhancement with olivine or steel slag on a coastal plankton community in Tasmania

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Ocean alkalinity enhancement (OAE) aims to increase atmospheric CO_2 sequestration in the oceans through the acceleration of chemical rock weathering. This could be achieved by grinding rocks containing alkaline minerals and adding the rock powder to the surface ocean where it dissolves and chemically locks CO_2 in seawater as bicarbonate. Here, we used 53L microcosms to test how coastal plankton communities from Tasmania respond to OAE with olivine or steel slag as alkalinity sources. Three microcosms were left unperturbed and served as a control, three were enriched with olivine powder (1.9 g L^{-1}), and three with steel slag powder (0.038 g L^{-1}). Microcosms were monitored for 21 days. Olivine and steel slag additions increased total alkalinity by 29 µmol kg^{-1} and 361 µmol kg^{-1}. Olivine and steel slag released silicate nutrients into the water column, but steel slag released considerably more phosphate. There was no significant difference in total chlorophyll *a* concentration between the treatments and the control. However, the maximum quantum yields of photosystem II (F_v/F_m) were higher in slag and olivine treatments, suggesting that mineral additions increased photosynthetic performance. The zooplankton community composition was also affected with the most notable changes being observed in the dinoflagellate *Noctiluca scintillans* and the appendicularian *Oikopleura* sp. Overall, steel slag is much more efficient for CO_2 removal with OAE than olivine and appears to be induce less changes in the plankton community when relating the CO_2 removal potential to the level of environmental impact that was observed here.

S03-17063 Oral (ECOP)

Mesopelagic-migrant pump contribution to Southern Ocean downward carbon export

Katherine **Baker**[1,2], Svenja Halfter[1,3], Ben Scoulding[4], Shane Richards[5], Caroline Sutton[4], Kerrie M. Swadling[1,2], Matthieu Bressac[1,6] and Philip W. Boyd[1,2]

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The passive flux of particles through the biological carbon pump is a long-established mechanism for carbon export. However, carbon-rich particles can also be actively injected to deep waters through the diel vertical migration (DVM) of biota from the surface to the ocean twilight zone (200-1000m), termed the mesopelagic-migrant pump (MMP). We investigated the magnitude of the MMP in December 2020 – January 2021 during the SOLACE (Southern Ocean Large Areal Carbon Export) voyage. DVM and micronekton community composition were investigated using a suite of complementary sample methods including RMT-16 net trawls, acoustics, and imagery. Downward carbon export was estimated through four pathways, i.e., faecal pellet and carcass production, excretion, and respiration, to understand how discrete micronekton groups contributed to the MMP at each site. Blooms of two migratory tunicate species, the pyrosome Pyrosoma atlanticum and the salp Salpa thompsoni, were observed to dominate the biomass at the three Southern Ocean sites sampled, north and south of the Polar Front (PF). Results from SOLACE suggest these blooms make the largest contribution to the MMP and active carbon flux estimates are within one order of magnitude as the gravitational flux. However, gelatinous blooms are patchy and episodic. Future work necessitates linking gelatinous blooms to environmental drivers to address MMP seasonality. A better understanding of the seasonality in the strength of the MMP will enable improved projections of downward carbon export in the Southern Ocean.

S03-17070 Oral (ECOP)

Long-term monitoring of zooplankton-mediated fecal pellet carbon fluxes in the Pacific Arctic region

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To assess the role of zooplankton fecal pellets in the biological carbon pump of the Pacific Arctic region, long-term sediment traps were deployed at the KAMS1 (KOPRI Arctic Mooring Systems) and KAMS2 mooring sites over the East Siberian Sea and Chukchi Sea slopes. Sediment traps placed at KAMS1 (115 and 335 m) and KAMS2 (325 m) sampled at intervals ranging from two weeks to a month from August 2017 to August 2019. Zooplankton fecal pellets and zooplankton (swimmers) obtained in the traps were quantified, and the contribution of fecal pellet carbon (FPC) to the particulate organic carbon (POC) flux was determined. At KAMS1, an increase in FPC fluxes in July 2018 due to enhanced food availability coincided with the onset of an under-ice bloom. At KAMS2, FPC fluxes were relatively low prior to the ice melt period, suggesting a larger proportion of smaller pellets produced by a predominance of small copepods under relatively warmer conditions in 2018 in the Chukchi Sea. Sustained FPC fluxes from January to May 2018 at KAMS2 contributed up to 24% of the POC fluxes, and it may have resulted from pellet production by omnivores grazing particles transported with the Chukchi Slope Current during that period. Swimmers were mostly copepods that are often found in deeper layers, and amphipods and ostracods were also present. These results suggested that FPC fluxes over the East Siberian Sea and the Chukchi Sea slopes differed due to food availability of zooplankton and their composition.

S03-17162 Oral (ECOP)

Lipid biomarkers and stable isotopes reveal disconnect between feeding dynamics of mesopelagic zooplankton and particulate organic matter during a sinking diatom bloom in the Scotia Sea (Southern Ocean)

Eloïse L-R. **Savineau**[1,2], Kathryn B. Cook[1,3], Sabena J. Blackbird[4], Gabriele Stowasser[5], Konstadinos Kiriakoulakis[6], Calum Preece[4], Sophie Fielding[5], Anna C. Belcher[5], George A. Wolff[4], Geraint A. Tarling[5] and Daniel J. Mayor[1,3]

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Mesopelagic zooplankton play an important role in the cycling of carbon via the biological carbon pump, however, little is known about the physiology and ecology of key taxa found within this region. We sampled eight key zooplankton species from within the mesopelagic zone in the Scotia Sea during a sinking diatom bloom, alongside vertical profiles of particulate organic matter (POM), to investigate their ecology using lipid biomarkers and stable isotopes. Biomarker data suggest that the large herbivorous calanoid copepods, *Rhincalanus gigas* and *Calanoides acutus*, were in, or emerging from, a period of metabolic inactivity during the study period. Their abundant lipid reserves suggest they may have been metabolising previously stored lipids, rather than deriving energy solely from the diatom bloom. This highlights the importance of the timing of emergence from diapause of overwintering species as this may impact turnover of POM in the upper mesopelagic. The $\delta^{15}N$ signatures of POM became increasingly enriched with increasing depth, whereas those of zooplankton did not, suggesting that actively feeding animals were consuming fresher, surface-derived POM, rather than reworked particles at depth. This indicates a decoupling between the feeding dynamics of zooplankton and ambient POM throughout the upper 500 m. An increased contribution of copepod lipids to POM was clear at the boundary of the epi- to mesopelagic suggesting that small, particle-associated copepods are important in the reworking of sinking POM in this region. We highlight the importance of considering zooplankton physiological ecology when investigating carbon flux in the upper mesopelagic.

S03-17174 Oral (ECOP)

The aggregation of phytoplankton into "food boluses" through feeding by Antarctic krill and its implications for organic matter export

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In our laboratory-based investigation, we explored an intriguing phenomenon of food bolus formation by Antarctic krill, where krill externally aggregate food particles into substantial masses within their feeding apparatus before subsequently rejecting them. Our study aimed to understand the mechanisms of bolus formation by studying krill feeding behaviour and assessing the potential significance of boluses in the export of organic matter.
We observed two distinct scenarios that can lead to the formation of boluses: 1) when concentrations of food items are too high for krill to efficiently filter feed; and 2) when either biological or foreign particles are caught in the feeding basket and are unable to be processed by the krill. We conducted comprehensive analyses, including the quantification of bolus rejection rates, determination of bolus composition, measurement of sinking velocities, and assessment of carbon and nitrogen contents. Our findings suggest that this behaviour may not be confined to laboratory conditions but could also occur in situ among Antarctic krill populations. Should this event prove to be prevalent in the wild, it could potentially constitute a to-date unknown pathway for the transportation of organic matter to greater ocean depths.

S03-17248 Oral

Moult flux: its measurement in Antarctic krill and biogeochemical significance in the Southern Ocean

Clara Manno, Sophie Fielding, Gabi Stowasser, Sally E. Thorpe and Geraint A. **Tarling**

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Antarctic krill play an important role in biogeochemical cycles in the Southern Ocean and can potentially generate high particulate organic carbon (POC) fluxes to the ocean interior. To date, parameterisations have focussed on the krill faecal pellet (FP) contribution to POC flux. However, krill may also contribute through cast exuviae during moulting and their own carcasses post-mortality. We considered the contribution of each of these krill-derived sources of POC in sediment trap samples in the north Scotia Sea (specifically on the South Georgia shelf). We found that krill can be a dominant contributor to POC flux in this region, comprising 92% of annual total POC export. The contribution of exuviae to this flux was found to be equal to that of FP over the annual cycle. Krill exhibit continuous moulting at rates closely associated to body size and temperature. Inverse modelling of these parameterisations estimated the krill population density that generated the observed flux of exuviae to be up to 261 g m^{-2} at its peak. These values correspond well with bioacoustic surveys of krill biomass in this region. Overall, the combination of FP and exuviae flux can substantially augment the total flux of POC to levels > 460 mg m^{-2} d^{-1}, which is an order of magnitude greater than that observed even in highly productive, iron-fertilised regions within the Southern Ocean (POC flux up to 23–27 mg m^{-2} d^{-1}). We further consider new technologies and parameterisations that can refine further the measurement of krill moult flux into the future.

S03-17252 Oral

Carbon budgets of Scotia Sea mesopelagic zooplankton and micronekton communities during austral spring

Kathryn B. **Cook**[1,6], Anna Belcher[2], Daniel Bondyale Juez[3], Gabriele Stowasser[2], Sophie Fielding[2], Ryan A. Saunders[2], Mohamed A. Elsafi[4], George A. Wolff [5], Sabena J. Blackbird[5], Geraint A. Tarling[2], Daniel J. Mayor[1,6]

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Zooplankton form an integral component of pelagic ecosystems, and we need to better understand their role in ocean biogeochemistry. The export of particulate organic matter to depth plays an important role in controlling atmospheric CO2 concentrations. Pelagic mesozooplankton and micronekton communities influence the fate of organic matter via consumption and export of material as fast-sinking faecal pellets, and active flux by animals undertaking diel vertical migration (DVM). We present day/night vertical biomass profiles of mesozooplankton and micronekton in the upper 500 m at an ocean observatory station (P3) near South Georgia (Scotia Sea) in austral spring, alongside estimates of their daily rates of ingestion and respiration. Day and night community biomass estimates were dominated by copepods, including the lipid-rich species, Calanoides acutus and Rhincalanus gigas. We found little evidence of synchronised DVM, with only Metridia spp. and Salpa thompsoni showing consistent migratory behaviour. At depths below 250 m, estimated community carbon ingestion rates exceeded those of metabolic costs, supporting the understanding that food quality in the mesopelagic is relatively poor, and organisms must consume a large amount of food to fulfil their nutritional requirements. By contrast, estimated community rates of ingestion and metabolic costs at shallower depths were approximately balanced, but only when we assumed that animals were predominantly catabolising lipids (i.e. respiratory quotient = 0.7) and had relatively high absorption efficiencies. Our work highlights the need for a better understanding of the physiology of lipid-storing animals and how it influences carbon budgeting in the pelagic.

S03-17314 Oral

Variability of active flux by zooplankton and micronekton in the ocean

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Among the three main mechanisms of the biological carbon pump (BCP), active flux is by far the less studied. Zooplankton active flux was recognized long ago as a significant component of the BCP transporting carbon downward in the ocean, and we are starting to have an important knowledge about its magnitude and spatial and temporal variability. Studies related to active flux by micronekton, by opposite, are much scarcer mainly due to a gap in sampling these communities on board research vessels. We are starting to have data about the role of mesopelagic fishes and large crustaceans (e.g., decapods) in the BCP. However, the estimation of mesopelagic fish biomass is still a cornerstone for a complete assessment of active flux. Some new methodologies based on acoustic and optical systems are providing additional data showing that these organisms are highly underestimated using trawls. Even fewer studies estimate active flux by both zooplankton and micronekton communities. So, there is an urgent need to perform active flux assessments by both communities as well as other poorly studied components of the BCP such as pyrosomids, salps, or other gelatinous plankton. Here, I review the state-of-the-art of active flux in the ocean, its variability, gaps, and its relationship with ocean primary production. Knowledge of active flux by zooplankton and micronekton must be extended in the near future in order to provide the necessary information to build realistic BCP models, as well as the estimation of carbon drawdown by the ocean using remote sensing technologies.

S03-17330 Oral (ECOP)

Contribution of a major zooplankton vertical migrator to respiration flux: the case of *Metridia longa* in the Arctic.

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Marine zooplankton play a major role in augmenting the biological carbon pump (BCP) via several processes associated with their widespread vertical migration behaviour. One such way is through respiration, in which they ingest organic matter within the upper water layers before undertaking their downward vertical migration to regions below the mixed layer, where they respire and produce CO_2, contributing to the pool of dissolved inorganic carbon (DIC). However, quantifying this contribution is difficult due to variations in metabolic rates across temporal, spatial, and environmental ranges. We assessed the respiration rates of the vertical migrator, *Metridia longa* in the Arctic Ocean to understand the contribution their respiration makes to the BCP. *M. longa* were collected from two different depths and placed in individual wells, with a fluorescence-based respirometry system to measure their oxygen consumption. Our results revealed that weight specific respiration rates of *M. longa* varied with sex and differences in vertical distribution, and/or vertical migration behaviour. Females were found to have similar respiration rates and physiology, irrespective of collection depth, suggesting that females were well mixed through the water column. Males, by contrast, appeared to exhibit a distinct segregation between those collected from shallow depths and deeper populations. Males collected from deeper waters had lower respiration rates than their shallower counterparts. This study illustrates the complexity of determining levels of respiratory carbon flux generated by these migrating species as well as highlighting the need to consider community composition and dynamics when parameterising zooplankton contribution to the BCP.

S03-17412 Oral

ZooRespire – a less intrusive approach to measuring mesozooplankton respiration

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Mesozooplankton play a key role as particle flux feeders in both ocean ecology and biogeochemistry. They are viewed as the 'gate-keepers' of the oceans' biological carbon pump since they are thought to play an influential role in attenuating the downward flux of Particulate Organic Carbon (POC) into the oceans Twilight Zone. This zone, which straddles the upper mesopelagic from 100 to 500 m depth, presents major challenges to obtaining rates of the resident biota – the mesozooplankton and particle-attached heterotrophic microbes. The development of the CRESPIRE - a hybrid particle interceptor/incubator (https://aslopubs.onlinelibrary.wiley.com/doi/full/10.1002/lom3.10043) has enabled measurement of the respiration rates of particle-attached bacteria under in situ temperature and pressure in the Twilight Zone. However, this is only part of the particle flux attenuation story. Can we devise an approach to make such measurements in situ for mesozooplankton? The development of the ZooRespire involved overcoming a series of hurdles. First, could we attract animals into the open chamber in a manner to minimize any stress-related increase in their respiration rates? Second, could we optimize the chamber dimensions to maximise their 'stay-over comfort' but still be able to measure a respiration signal? Here, we present how we overcame these methodological obstacles to obtain rates of mesozooplankton respiration. To conclude, we report on our attempts to transition from a lab-based to a subsurface deployed instrument.

S03-17160 Poster (ECOP)

Estimating how vertically migrating zooplankton impact epipelagic communities with mesocosm experiments

Alice **Della Penna**[1,2], Gérald Gregori[3], Mark Ohman[4], Loic Guilloux[3], Morgane Didry[3], Andrea Doglioli[3], François Carlotti[3]

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Vertically migrating zooplankton play a key role in the carbon pump by transporting particulate and dissolved carbon from the epipelagic to the deep ocean. Monitoring the variability in grazing and predation by vertically migrating zooplankton on epipelagic organisms is challenging and labor-intensive, but essential to properly characterize the role of zooplankton in the carbon cycle. We tested the use of a mesocosm experiment to assess the impact of vertically migrating zooplankton on epipelagic plankton. Our experiment consisted in filling two 400L mesocosms with water from the same water mass but collected at different times: one of the mesocosm was filled before sunset and contained the day time community; the other was filled after sunset and contained the night time community which included vertically migrating zooplankton. The two mesocosms were incubated for the entire night and the distribution of phytoplankton was monitored using flow-cytometry and imaging. We used these measurements to assess the differences between these two mesocosms, from one of which vertically migrating zooplankton were excluded, and evaluate whether this approach can be used to quantify the impact of vertically migrating zooplankton on epipelagic plankton as a bulk. We also analysed repetitions of this experiment from different areas to investigate the spatial variability of this impact. We propose this mesocosm-based bulk approach as complement to existing measurements of grazing from gut content, to provide new insights on the spatial and temporal variability of grazing.

S03-17366 Poster (ECOP)

The impact of seasonally migrating copepods on the active carbon flux in the Southern Ocean

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The biological pump is an important transport mechanism of carbon into the ocean's interior. Typically, passively sinking particles, such as phytoplankton aggregates and zooplankton faecal pellets, are considered in global estimates of carbon export. However, the active injection of carbon by zooplankton migration can be an integral component of the total flux. In many parts of the ocean, zooplankton perform seasonal migrations to depths between 500 and 1,200 m as an overwintering strategy. During winter, the respiration of lipid reserves and carcass production can lead to a significant injection of carbon into the deep sea. This Seasonal Lipid Pump (SLP) is studied well for copepods in the higher latitudes of the Northern Hemisphere, while only a few studies focus on the Southern Hemisphere. In this study, we estimated the magnitude of the SLP for the subantarctic Southern Ocean by the copepod species *Neocalanus tonsus*. Copepod abundance data from three field campaigns south of Australia (spring 2018, summer 2020/21, and winter 2023) are used to understand the seasonal standing stock of carbon and migration depth. With literature values and laboratory measurements of metabolic rates and carbon content, we then estimate the SLP within the distribution range of *N. tonsus*. Additionally, we compare the SLP magnitude to other carbon transport pathways in the Southern Ocean, as well as to previous estimates of the SLP globally. Finally, we discuss current limitations in calculating the SLP magnitude as well as a way forward for better integration of seasonal migration into carbon flux models.

Session 4: Shedding new light on zooplankton: Unveiling communities, ecology, and evolution through integrated approaches

Convenors:
Astrid Cornils (Germany), corresponding
Silke Laakmann (Germany)
Sanna Majaneva (Norway)
Julian Uribe-Palomino (CSIRO)

Invited Speakers:
Katja Peijnenburg (Naturalis Biodiversity Center; Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Netherlands)

Anthropogenic activities have altered the biodiversity and geographic ranges of zooplankton as well as many of the pelagic habitats they occupy. These changes have impacts on ecosystem function and their food webs, thus, knowledge on zooplankton species diversity, distributions, ecology and evolution will continue to be essential for understanding and predicting the complex changes in marine ecosystems. Molecular, optical, and acoustic methods have been rapidly improved in the last decades to explore and monitor different aspects of zooplankton. Each of these methods, however, has different strengths and weaknesses and can independently only detect certain aspects of the impact from environmental change on zooplankton communities. The combination and integration of diverse methods provides the opportunity of a new perspective on the biodiversity, biogeography, ecology, and evolution of zooplankton. Integrated approaches offer unprecedented insights into the intricate dynamics of zooplankton communities, their ecological interactions, and evolutionary trajectories. This symposium invites contributions that validate, calibrate, and optimize methodologies as well as research on zooplankton diversity, ecology, and evolution, showcasing how integrated approaches provide a deeper understanding of these organisms within the context of global change.

04-17712 Invited

Convergent evolution obscures identification of bio-indicators of ocean change

Katja T.C.A. **Peijnenburg**[1,2], Giada Spagliardi[1], Paula Ramos-Silva[1,2], Le Qin Choo[1,3], Luigia Donnarumma[4], Erica Goetze[5], Galice Hoarau[6], Ferdinand Marlétaz[7]

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Genetic data indicate that many widely distributed zooplankton species are actually composed of multiple biological species. Neglecting this can lead to confusion, underestimating biodiversity and hindering our understanding of ecological and evolutionary processes.
This talk will focus on shelled pteropods of the genus *Limacina*, which are regarded as sensitive bio-indicators to assess the impacts of ocean acidification. They have aragonitic shells and are shown to be highly sensitive to changes in ocean chemistry. However, distinct species have different vulnerabilities and responses to climate change and currently, the taxonomy and evolutionary history of *Limacina* species is unresolved. Especially in the two nominal species with cold-water, bipolar distribution patterns (*Limacina helicina* and *L. retroversa*), several subspecies have been described that are often confused.
Here, we used an integrative taxonomic approach combining morphometric and phylogenomic approaches to resolve species boundaries, as well as their phylogeny and timing of evolution. We found that similar shell shapes evolved independently in both hemispheres and that morphology can be misleading in identifying species. Furthermore, we show that species with similar shell shapes can have millions of years of independent evolution and divergent calcification patterns. These northern and southern hemisphere polar species are likely to have very different ecologies, which will affect their responses to ocean change.

S04-17069 Oral (ECOP)

Distributional ranges of mesopelagic zooplankton across the North Pacific Basin: testing the effects of physical dispersal vs. environmental homogeneity

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The biogeographic distributions of mesopelagic zooplankton are not well defined. At basin scales, epipelagic zooplankton communities are often associated with major oceanographic circulation features with distinct biogeochemical environments. However, slower physical circulation and increased environmental homogeneity in the deep ocean may lead to differences in biogeographic ranßges among zooplankton inhabiting different depths. We use metabarcoding of two molecular markers (18S and COI) to assess zooplankton community composition in the upper 1000 m of the water column at 28 locations across the North Pacific Ocean, between 0 – 57 °N and 138 °E – 118 °W. We compare distributional ranges and community similarity within epipelagic and mesopelagic depth zones to test the relative effects of dispersal potential and environmental selection. We report larger temperature, salinity, and dissolved oxygen ranges as well as narrower potential food ranges for deeper-dwelling taxa across the North Pacific. We find significant relationships between community dissimilarity and dispersal distance, as well as between community dissimilarity and differences in temperature, salinity, dissolved oxygen concentration, and food flux. Our results indicate that epipelagic and mesopelagic zooplankton communities have similar levels of horizontal community similarity structure (i.e., species composition and biodiversity), despite differences in the magnitude of environmental gradients and dispersal potential. Biogeographic patterns in epipelagic and mesopelagic zones of the North Pacific are then best explained through a combination of dispersal potential and environmental selection.

S04-17091 Oral (ECOP)

Molecular characterization of the deep-sea zooplankton community from the Gulf of Alaska Seamount Province

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Most data on zooplankton diversity in the North Pacific comes from collections obtained from the epipelagic zone, with occasional collections across the basin contributing mesopelagic data down to 1,000 m. In 2019, zooplankton communities were sampled from surface waters to the abyssal plane (4,500 m) around the Quinn and Giacomini seamounts that form the northwestern section of the Kodiak-Bowie Seamount Chain in the Gulf of Alaska. Depth-stratified zooplankton samples were collected with MultiNet and MOCNESS plankton sampling net systems in addition to video footage and specimen collections from a remotely operated vehicle (ROV). We report on the molecular characterization of these rarely sampled zooplankton communities using metabarcoding analyses targeting the mitochondrial cytochrome oxidase I (COI) and the nuclear 18S rRNA genes. As the accuracy and level of biodiversity detected from metabarcoding are dependent upon the quality of DNA sequence reference libraries, a considerable amount of effort was made to identify and voucher specimens collected during the expedition for DNA barcoding. Thus, we also report on the status of DNA barcoding for multiple genetic markers for over 1,200 organisms from depths beyond 1,000 m. These results represent the first recorded observations for many zooplankton species in the Gulf of Alaska, species new to science, and new DNA barcodes. Efforts from this work are helping to characterize deep-sea zooplankton communities and, overall, increase biodiversity estimates for the entire Gulf of Alaska ecosystem.

S04-17095 Oral

DNA metabarcoding reveals the community structure of copepod nauplii in the Japan Sea

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Copepod nauplii are ecologically important as a prey of many fish larvae; however, their community structures have been unexplored at the species-level due to difficulties in morphological classification. Here, we used a metabarcoding approach of 28S and COI regions to reveal the community structure of copepod nauplii with high taxonomic resolutions in the Japan Sea. Zooplankton samples were collected at 0–50 m by vertical hauls of a 0.06 mm mesh net between February 2022 and January 2023. The 28S and COI metabarcoding analysis revealed clear differences in community structures both in adults and nauplii between cold (January-June) and warm (September-November) periods, which were strongly influenced by the dominance of the Tsushima Warm Current (TWC). The species diversity based on operational taxonomic units (OTUs) was high in adults and nauplii during the warm period, suggesting that the TWC introduced warm-water species with high diversity to the Japan Sea. The result of 28S showed that major OTUs were common between adult and nauplius communities in each season except for June, when the TWC started to dominate in the Japan Sea. In June, the OTUs identified as cold-water species, such as Oithona atlantica and Metridia pacifica, were not dominant in the adult but in the nauplius communities. This discrepancy might be associated with changes in environmental conditions induced by the TWC, which affected some cold-water species' growth, reproduction, and vertical distribution. A detailed analysis of COI including cryptic species is needed for a further understanding of nauplius community in the Japan Sea.

S04-17096 Oral (ECOP)

Global species diversity of pelagic polychaetes in the family Tomopteridae as revealed by molecular approaches

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Tomopteridae is a common pelagic polychaete family with ubiquitous distributions in the global ocean. However, the species diversity of tomopterids is poorly understood because their fragile gelatinous bodies often lose important morphological traits for species identification during collection and preservation. To understand the global diversity of pelagic polychaetes, the species diversity and distribution of Tomopteridae were investigated using molecular approaches in the Pacific, Indian, and Atlantic Oceans. We performed phylogenetic analyses based on mitochondrial COI for a total of 536 specimens collected at 43 stations. Operational taxonomic units (OTUs) were defined based on COI sequence similarity (≥2.4%) and nuclear 28S and genome-wide SNP detected populations. A total of 35 OTUs and 17 phylogenetically-distinct singletons were identified. The largest number of OTUs was observed in the Pacific Ocean (24 OTUs, *n*=369), followed by 8 OTUs in both the Indian (*n*=80) and Atlantic Oceans (*n*=84). Most OTUs were restricted to a single ocean, with only 3 OTUs common across all oceans. The distributional patterns of OTUs in each ocean corresponded to large-scale ocean circulation and distinct marine environments. Endemic OTUs were primarily detected at high latitudes and in transition zones; Cosmopolitan OTUs were distributed at lower latitudes in the subtropics and tropics. These results suggest that most tomopterid species are specialized to a particular area within each ocean, and both physiological isolation and environmental conditions may be important factors for speciation of the Tomopteridae.

S04-17102 Oral

Metabarcoding Zooplankton Diversity: MetaZooGene Intercalibration Experiment (MZG-ICE)

Ann **Bucklin**[1], Leocadio Blanco-Bercial[2], Ruben Escribano[3], Tone Falkenhaug[4], Junya Hirai[5], Jenny Huggett[6], Pedro Martinez[7], Katja Peijnenburg[8], Leonie Suter[9], Agata Weydmann-Zwolicka[10], Paola Batta-Lona[1], Stacey Dubbeldam[8], Elizaveta Ershova[4], Carolina E. Gonzalez[7], Ashrenee Govender[11], Johan Groeneveld[11], Sahar Khodami[7], Anna MacDonald[9], Monika Mioduchowska[10], Andrea Polanowski[9], Jasmin Renz[7], Peter Wiebe[12], Todd O'Brien[13]

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The MetaZooGene Intercalibration Experiment (MZG-ICE) is a research collaboration designed to examine the variability, reproducibility, and reliability of multi-gene metabarcoding of zooplankton samples. The project includes 10 research teams affiliated with WG157 of the Scientific Committee for Oceanic Research (SCOR) https://metazoogene.org/. Each MZG-ICE team selected one zooplankton sample for analysis and carried out DNA extraction and purification protocols typically used in the laboratory. DNA aliquots were distributed to MZG-ICE laboratories for sequencing of four gene regions: mitochondrial COI and V1-V2, V4, V9 hypervariable regions of 18S rRNA. Standardized protocols were recommended; alternative procedures (PCR primers and protocols, library preparation, sequencing depth) were accepted as necessary to ensure sequence data quality. The resulting raw data files were uploaded to a central database for bioinformatics and statistical analysis carried out by a team of MZG-ICE participants, who agreed upon approaches for quality assurance / control, taxonomic analysis, diversity statistics, and multi-factor intercomparisons. Several bioinformatics pipelines and numerous statistical programs were used. The reference sequence database used for classification and identification of sequences was the MZGdb Atlas and Database https://metazoogene.org/mzgdb/. MZG-ICE allowed examination of impacts and consequences of different laboratory protocols and procedures and evaluation of the reliability of DNA metabarcoding for analysis of zooplankton diversity at multiple levels – from species to taxonomic groups. Continued communication and coordination across the research community is needed to improve molecular metabarcoding analysis of zooplankton biodiversity and guide applications for assessment and management of marine ecosystems.

S04-17111 Oral (ECOP)

Copepod-virus interactions revealed by molecular and morphological approaches

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We focused on previously overlooked interactions between copepods and viruses in the marine ecosystem using molecular and morphological approaches. Zooplankton samples were collected weekly in March-July 2020 in the coastal water of the Okhotsk Sea. The copepod Pseudocalanus newmani, the dominant zooplankton in winter-spring in the Okhotsk Sea, was selected and picked up from bulk zooplankton samples. A transcriptome analysis with rRNA depletion revealed four new RNA viruses from P. newmani, which were closely related to the Narnaviridae (PSNE-Narna), Picornavirales (PSNE-Pico1 and PSNE-Pico2), and Togaviridae (PSNE-Toga). RT-qPCR revealed different seasonal peaks of copy number and prevalence in each virus, and all viruses were detected during the low-abundance period of P. newmani. An apparent physiological change of P. newmani, investigated by a transcriptome analysis with Poly(A) selection, was only found in P. newmani with high viral loads of PSNE-Pico1. Thus, we focused on P. newmani with PSNE-Pico1, and viral-like particles were observed in a gut content and copepod intestine using transmission electron microscopy from P. newmani during high prevalence of PSNE-Pico1. The phylogenetic analysis classified PSNE-Pico1 into Marnaviridae in Picoenavirales, a family of phytoplankton viruses. Additionally, diet analysis based on 18S metabarcoding showed that the major prey of P. newmani was diatom through the sampling period, suggesting that PSNE-Pico1 was horizontally transmitted from a food source to copepods. These results indicated that some marine viruses might be associated with population dynamics and physiological conditions of copepods, and copepod-virus interactions including a transmission pattern should be further investigated to understand marine ecosystems.

S04-17124 Oral

A sea of jellies is a sea of worms: a look at the parasitic component of gelatinous zooplankton in fjord systems through an integrated approach.

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Parasites play a vital role within zooplankton communities. However, our understanding of the diversity of helminth parasites (i.e. nematodes, trematodes, cestodes) affecting gelatinous zooplankton remains limited, despite their significant impact on regulating the populations of economically important hosts. Inside jellyfish these parasites primarily occur in their larval stage, hindering species identification based solely on morphological characters. This work discusses the challenges and implications of these associations based on a case study involving the parasites of cnidarian and ctenophoran jellyfish in two Norwegian fjords. We conducted a year-long monthly survey in which the identity, host range, prevalence, and intensity of these parasites were monitored using an integrative approach that combined morphological identification and DNA barcoding with the additional objective of creating reliable DNA reference databases for all organisms involved. Both hosts and parasites belonged to phylogenetically diverse sets of organisms including ca. 20 species of hydromedusae, siphonophores, scyphomedusae, and ctenophores that were parasitized by members of at least 7 different families of helminths, some of which eventually parasitize commercially valuable fish (e.g. the nematode Hysterothylacium aduncum, and the trematode Derogenes varicus). The most prevalent interaction observed involved metacercaria-stage trematodes parasitizing hydromedusae, which account for more than 90% of the interactions observed. Occasionally, individual jellyfish carried exceptionally high parasitic loads, with intensity values exceeding 2300 metacercariae per host. The contribution of massive infections to the decline of jellyfish blooms, and the potential of eDNA metabarcoding for the continuous monitoring of zooplankton parasites, is discussed based on our findings.

S04-17133 Oral

20 years of jellies in the same fjord: From morphology to molecules, and what have we learned?

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In 2003, a comprehensive seasonal study of the gelatinous zooplankton communities of Korsfjord and Fanafjord, Norway, was conducted using net sampling and morphological methods only (Hosia and Båmstedt 2007). In 2023, the study was repeated using a reduced sampling design, but also including trials for eDNA based monitoring of the gelatinous fauna. In the meantime, Norwegian Taxonomy Initiative projects HYPNO, NorHydro, GooseAlien and, most recently, NOAH, have focused on DNA barcoding and integrative taxonomy of the hydrozoan and ctenophoran fauna of Norway, producing novel knowledge on the diversity of these taxa in the study region. Combining morphological and molecular methods has contributed to resolving several taxonomic issues, such as linking benthic and pelagic life stages, as well as revealed cryptic diversity in several of the genera. The resulting comprehensive reference library of reliable DNA barcodes (COI, 16S and/or 18S) from the study region also facilitates assigning species names to gelatinous zooplankton sequences in metabarcoding applications.

S04-17134 Oral (ECOP)

Latitudinal gradients in zooplankton communities in Norwegian fjords resolved by an integrated morphological and molecular approach

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Fjords are unique coastal features carved by glaciers during the last ice age that were flooded by rising sea levels when the glaciers retreated. They can be very deep (>500m) and extend far inland, creating complex and oceanographically distinct environments. Here, we offer a comprehensive overview of zooplankton communities at the end of the productive season across 17 fjords along the Norwegian west coast, ranging in latitude from 62 to 69°N. We apply an integrated methodological approach which included microscopic analysis, FlowCAM image analysis, community DNA metabarcoding, and bulk size-fractionated biomass measurements. Together, these combined data revealed distinct geographical patterns in zooplankton quantity and community composition. Water temperature, bottom depth, and fjord sill depth were the most important parameters driving zooplankton biomass, abundance, community structure and size distribution. Multivariate analysis of species composition of using both microscopy and metabarcoding-derived data identified three distinct assemblages which were strongly correlated to latitude and bottom depth. We also discuss the strengths and limitations of each of the applied methodologies and advocate for the integration of multiple distinct methods to provide a comprehensive and unbiased evaluation of planktonic communities.

S04-17138 Oral

Molecular biogeography of the genus *Stylocheiron* (Euphausiacea) unveils high cryptic or pseudocryptic diversity and conspicuous geographical patterns in the Atlantic Ocean

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The euphausiid genus *Stylocheiron* is widely distributed throughout tropical and temperate regions of the Atlantic, Pacific, and Indian oceans. This genus includes the smallest representatives of the family, occurring in the epi- or meso-, and bathypelagic and nearly not migrating diurnally. We collected all eight currently accepted Atlantic species of the genus (only four Indian-Pacific species were out of our scope) and analyzed their diversity and population structure throughout the Atlantic Ocean (60°N-46°S; over 400 specimens) using the mitochondrial cytochrome oxidase I (COI) barcode region. Phylogenetic and species delimitation analyses suggested 14 cryptic or pseudocryptic species, mainly within the *Stylocheiron longicorne* species group. Two species of this group, *S. affine* and *S. longicorne* , comprise several paraphyletic molecular lineages each. Some of these lineages are associated with different morphological forms previously described by E. Brinton. We recorded several biogeographic patterns in distribution of *Stylocheiron*: (1) genetically cohesive species with wide distributional range (~40°N-40°S), (2) species/molecular lineages encompassing two genetically cohesive but geographically distinct populations; (3) molecular lineages with a restricted geographical range, at least in the Atlantic Ocean. The biogeography of the genus *Stylocheiron* in the Atlantic is much less studied compared to the Pacific and Indian Oceans. This study would contribute to our knowledge of plankton diversity, population connectivity, community structure and sustainability to global change.

S04-17159 Oral (ECOP)

How methods influence results: comparing morphological vs molecular identification of zooplankton for biodiversity studies and to answer ecological questions, and the possibility of combined methods

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Zooplankton in the water column can be identified with both morphological and molecular techniques. However, there are benefits and drawbacks to each method, and the data from each may even produce differing conclusions about the ecology of the system. Here, we sampled zooplankton from the Choptank River, a brackish tributary of the Chesapeake Bay in Maryland, USA. Our samples were collected from May – September in 2018 and 2019, along a salinity gradient from 0.1 to 14 ppt. Zooplankton samples from the water column were identified using traditional morphological methods (microscopy) and metabarcoding with marker cytochrome oxidase 1 (CO1). The data were compared across methods for taxonomic resolution, quantitative accuracy, and common measures of community composition and diversity, as well as for time investment and cost of generating the data. The data were also used to answer common ecological questions about the system (e.g. physical drivers of diversity, community composition across salinity gradient and season, etc.), and these results compared across methods. Finally, the strengths of each method were identified, and an attempt was made to apply these strengths across methods to evaluate the utility of using both methods simultaneously. Our findings suggest benefits and challenges to using these methods for monitoring and ecological process studies.

S04-17179 Oral

How soft and small can specimens be for creating 3D digital models of Zooplankton specimens?

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Methods such as Computed Tomography (CT) scanning produces very high-resolution imagery, allowing the reconstruction of internal and external features of the specimen This technique is now being applied as a novel method for digitalisation of specimens from Natural collections. However, there have been few attempts to apply this technique to the digitalisation of small specimens (< 10 mm in length), such as zooplankton, because they need to remain in a liquid medium. Here we present results from Micro CT scanning a series of zooplankton specimens of different sizes and with a variety of body structures and compositions. Our preliminary results using the dye Phosphotungstic Acid (PTA) shows high potential for digitalisation of specimens with soft bodies such as gelatinous plankton and for specimens with a mixture of tissues such as fish larvae. Furthermore, we suggest that this technique might not be suitable for specimens < 0.6 mm in length, although complementary techniques such as Confocal Laser Scanning Microscopy could potentially provide good reconstruction of very small specimens with a high resolution of detail for external morphology. This research constitutes a novel way to digitalise and visualise specimens down to resolutions of 1-2 □m, leading to the possibility of using the 3D models for taxonomic, morphological and computational purposes. Our results will enable the establishment of future digital collections, virtual reality and AI applications.

S04-17183 Oral->Poster

New kid on the block - proteomic fingerprinting as quick and easy molecular tool for species identification in monitoring of marine zooplankton communities

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Presented by Silke Laakmann on behalf of Janna Peters

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Rapid species identification is a major challenge in monitoring zooplankton and assessing the biodiversity of marine communities. Over the past decade, a wide range of molecular methods have been integrated into marine zooplankton research. Each of these methods provides a different level of information depth and efficiency. Through a series of case studies, we demonstrate that proteomic fingerprinting, a method commonly used in microbiology and pathogen research, serves as a novel, time- and cost-efficient tool for identifying metazoan species. In this method, small cytosolic molecules (<15kDa) are rapidly extracted from tissue, and the mass composition is analyzed by Matrix Assisted Laser Desorption Ionization Time of Flight Mass Spectrometry (MALDI-TOF MS). While it was not possible to identify individual species-specific markers, marker patterns have been shown to be highly stable, as demonstrated by a cross-taxa study of more than 200 marine species. While marker expression can be influenced by environmental factors, as shown by experimental and field studies on epipelagic copepods, a high degree of specificity can be achieved using various machine learning algorithms, such as random forest models. In addition to species information, valuable insights into ontogenetic stages or sex can be obtained. The successful application of proteomic fingerprinting to assess the biodiversity of meroplanktonic larvae in the North Sea underscores the method's potential to complement established marine monitoring procedures, particularly given the often challenging nature of their identification. This is particularly valuable when rapid and detailed taxonomic resolution is required alongside traditional morphological identification and counting methods.

S04-17186 Oral (ECOP)

An integrated approach to exploring zooplankton assemblages in a cyclonic eddy

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The strongest boundary current in the southern hemisphere, the Agulhas Current (AC), flows southwestward along the east and south coasts of South Africa, before changing direction and retroflecting back towards the Indian Ocean as the Agulhas Return Current (ARC). An early (more eastward than normal) retroflection of the AC in May 2022 caused the formation of a trapped, lee-edge cyclonic eddy between the continental shelf edge and the retroflecting current. A training cruise was diverted to study this rare feature, with hydrographic and net sampling conducted along a transect through the eddy. Bongo net tows were used to collect duplicate mesozooplankton (>200 µm) and macrozooplankton (>500 µm) samples in the upper 200 m. Zooplankton taxonomic- and size composition within the eddy were explored using a combined optical (image analysis) and molecular (DNA metabarcoding) approach. Image analysis of formalin-preserved samples was conducted using ZooScan, with taxonomic validation using EcoTaxa, yielding abundance, biovolume and size composition of the main taxa. Metabarcoding of ethanol-preserved bulk samples produced zooplankton species lists after matching sequences with reference barcodes on online databases. Results from the two methods were complementary, facilitating an integration of quantitative and community size metrics with presence / absence information at species level, including for rare and fragile species, and cryptic life stages (eggs, larvae, juveniles). An integrated approach provided a more comprehensive description of the zooplankton communities in the eddy than would have been possible with either method on its own.

S04-17187 Oral (ECOP)

Metabarcoding analysis for comparing epipelagic/mesopelagic zooplankton communities in the Pacific and eastern Indian Oceans

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Understanding a large-scale zooplankton community is essential for tracking changes in marine ecosystems in the global oceans; however, community structures of zooplankton in the Indian Ocean have been unexplored in interactions with the Pacific Ocean. Due to the difficulty in morphological classifications of zooplankton, we carried out metabarcoding analyses based on 28S and COI regions to compare zooplankton communities at epipelagic and mesopelagic layers between the ocean basins. Zooplankton samples were collected at three layers (0–200, 200–500, and 500–1,000 m) using VMPS at 51 stations in the Pacific and eastern Indian Oceans at low latitudes. The cluster analyses of 28S and COI revealed that zooplankton communities were mainly clustered into tropical and subtropical groups through the sampling layers in the Indian and Pacific Oceans, indicating the existence of common dominant species between ocean basins. The tropical group was characterized by relatively high chlorophyll *a* concentration, and the equatorial subgroup was observed in both ocean basins. Another subgroup was detected in the Bay of Bengal with unique environmental conditions in the Indian Ocean. The subtropical group was subdivided into inside and outside of the subtropical gyres only by COI with a high mutation rate. In the Indian and Pacific Oceans, the highest diversity was observed in the edges of subtropical gyres. These results suggested interactions of zooplankton species at each layer between the Indian and Pacific Oceans, and there were large impacts of environmental conditions on dominant species and diversity of zooplankton in local areas.

S04-17188 Oral (ECOP)

Zooplankton is the perfect candidate for validating eDNA metabarcoding for analyzing North Sea marine fauna

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Environmental DNA (eDNA) metabarcoding is gaining prominence in marine metazoan community assessments. However, uncertainties persist regarding eDNA's accuracy in capturing field diversity, highlighting the need for regional adjustments of the methodology ranging from sampling to completeness of open-access sequence data. In this study, we chose zooplankton as the perfect candidate to adjust and to validate the reliability of eDNA metabarcoding for marine fauna diversity assessments in the dynamic waters of Helgoland Roads, North Sea.
We assessed three assays, i.e. zooplankton identified via morphological diagnostic characters, zooplankton and eDNA metabarcoding (cytochrome oxidase c subunit 1 (COI) and 18S rRNA V4).   Compared to morphological identification, zooplankton metabarocoding revealed only a few false-negative detections.
Based on the zooplankton metabarcoding results, we checked eDNA metabarcoding detections for congruency and plausibility. In total, both zooplankton and eDNA metabarcoding identified 354 species from 16 metazoan phyla. These represent the well-known marine metazoan local and regional fauna as 95.9% (COI) and 81.9% (18S) overlap with the species documented in published morphological inventories, including rediscovered and neozoan species. Our results further demonstrated the sensitivity and efficiency in metabarcoding to recover holo- and meroplankton as it detected a quarter of all potentially occurring copepods in that area and meroplanktonic life-history stages across taxa. Half of the species were detected by both eDNA and zooplankton metabarcoding while the other species were preferentially detected specifically in eDNA or zooplankton. Our study validates molecular identifications and eDNA metabarcoding in identifying North Sea fauna and provide recommendations for sampling design for robust results.

S04-17199 Oral (ECOP)

Plankton community structure in response to hydrothermal iron inputs along the Tonga-Kermadec arc

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The Western Tropical South Pacific (WTSP) basin has been identified as a hotspot of atmospheric dinitrogen fixation due to the high dissolved iron ([DFe]) concentrations (up to 66 nM) in the photic layer linked with the release of shallow hydrothermal fluids along the Tonga-Kermadec arc. Yet, the effect of such hydrothermal fluids in structuring the plankton community remains poorly studied. During the TONGA cruise (November 2019), we collected micro- (20-200 mm) and meso-zooplankton (>200 mm) samples in the photic layer (0-200 m) along a west to east zonal transect crossing the volcanic arc, in particular two volcanoes associated with shallow hydrothermal vents (< 500 m) in the Lau Basin, and both sides of the arc represented by Melanesian waters and the South Pacific Gyre. Samples were analyzed by quantitative imaging and coupled with acoustic observations, allowing us to study the potential transfer of phytoplankton blooms to higher planktonic trophic levels. We show that micro- and meso-plankton exhibit high abundances and biomasses in the Lau Basin and, to some extent, in Melanesian waters, suggesting that shallow hydrothermal inputs sustain the planktonic food web, creating productive waters in this otherwise oligotrophic region. In terms of planktonic community structure, we identified major changes with high [DFe] inputs, promoting the development of a low diversity planktonic community dominated by diazotrophic cyanobacteria. Furthermore, we used Lagrangian dispersal models and show that chlorophyll a concentrations were significantly higher inside the Lagrangian plume, confirming the profound impact of shallow hydrothermal vents on plankton production.

S04-17206 Oral

Understanding key drivers of evolution of the pelagic decapods

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Macroplanktonic and micronectonic decapods play a significant role in the pelagic ecosystems in the meso- and bathypelagic. A combination of morphological, molecular, and mathematical methods has unveiled various scenarios in evolution of dominant groups of higher crustaceans. Our revisions of the global fauna of Oplophoroidea, Benthesicymidae, Sergestoidea, and Euphausiacea have shown different evolutionary traits linked to various morphological structures. These traits are sometimes parallel, sometimes not. Coupled with our knowledge of the species ecology, the traits allow understanding mechanisms that drive evolution of morphological characters and diversification of the taxa. We describe some of these mechanisms and suggest forecasts for future evolution of groups under possible environmental changes. As a ‘by-product’ of our studies, we get a ‘natural systematics’ of the global fauna of important marine taxa.

S04-17216 Oral

Illuminating zooplankton diel vertical migration with eDNA metabarcoding in the polar night

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The vertical migration of zooplankton signifies the greatest synchronized animal movement of our planet. It is a geographically and taxonomically widespread behavior which may take place in different temporal and spatial scales and can be regarded as one of the most extensive and strongest reasons for the emergence of plankton patchiness. Patches along horizontal and vertical directions in the diel vertical migration may result from the species-specific behavioral responses to changes in ambient light levels during the diel cycle. In the high Arctic, this light-driven behavior has been recorded to occur throughout the year, from midnight sun to the polar night, and can potentially be disrupted by artificial light. While tracking individual zooplankton in their natural habitats remains a major challenge, resolving the species-specific spatial resolution in relation to light is becoming a doable task. In an *in situ* experiment we have applied a multi-tool approach to understand the effect of natural and artificial light on the DVM in high Arctic during polar night. By complementing traditional plankton net tows and acoustic data with environmental DNA metabarcoding and light measurements we have achieved taxonomically more comprehensive picture of the effect of light on the spatial distribution of zooplankton at different stages of the diel vertical migration. More species-specific understanding of this migration is also crucial in terms of climate change and carbon sequestration.

S04-17222 Oral (ECOP)

Environmental DNA captures temporal and vertical population dynamics of marine zooplankton

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Understanding the temporal and spatial distribution of zooplankton is critical to comprehend the dynamics of marine ecosystems. While traditional sampling methods have limitations in capturing the complete picture of heterogenous zooplankton communities, environmental DNA (eDNA) has emerged as a promising tool to enhance sampling intensity. We have evaluated the efficiency of eDNA as a complementary approach to microscopy in capturing zooplankton community dynamics. For many taxa of interest, the eDNA analysis show similar patterns of population dynamics as traditional net sampling, providing valuable insights into the temporal dynamics of individual zooplankton taxa when sampled with high frequency. For instance, we identified variations in the timing of the occurrence of certain zooplankton taxa between years, suggesting potential associations with alterations in oceanographic properties and water mass structure. This talk will address key lessons learned from study design and data interpretation, and underscore the potential of integrating eDNA analysis to complement and enhance the resolution of traditional zooplankton community monitoring.

S04-17240 Oral

Zooplankton in the surface waters through the Greenland Sea Gyre.

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In 2021, the Arctic Project CASSANDRA conducted a multidisciplinary cruise along the 75th parallel north through the Greenland Sea Gyre, where the exchange of water masses is closely linked to various processes such as the melting/formation of sea ice and the Atlantic water inflow. The activity was carried out as an Italian contribution to the internationally coordinated activities called Synoptic Arctic Survey 2020/22 (SAS). Zooplankton samples were collected with both a Manta net (333 µm; surface sampling) and WP2 (200 µm; vertically towed in the 100-0m layer). To our knowledge, this is the first study of neuston in this area. Fractional biomass (> 2 mm; 2-1 mm; 1-0.5 mm; 0.5-0.2 mm), abundance, and taxonomic composition were analysed. Biomass and abundance in surface waters followed the same trend as in the water column, with the highest values in the central part of the transect. Nevertheless, the surface samples were richer in organisms than those collected in the water column (mean abundance: Manta net: 1257±1110 ind m^{-3}; WP2 net: 492 ±387 ind m^{-3}). In the Manta samples, biomass was higher (mean 41±32 mgDM m^{-3} vs. 10±7 mgDM m^{-3}) and consisted of 60% organisms of size 1-2 mm, while in the WP2 net the > 2mm fraction was more abundant. Stereomicroscopic analyses revealed the presence of 11 and 27 taxa in the Manta and WP2 nets, respectively, with copepods of the genus *Calanus* being the predominant taxon. Molecular analyses (COI and 18S) are in progress and will improve the description of species diversity.

S04-17267 Oral (ECOP)

Spatial variability in the distribution of euphausiids in the NE Pacific during the 2022 IYS Pan-Pacific winter expedition

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Despite their key role in connecting phyto/zooplanktonic food webs to higher trophic level species, our understanding of the ecology of euphausiids in the NE Pacific (NEP) remains limited, particularly during winter months. Here we quantify the distributions and biomass of euphausiids during the 2022 International Year of the Salmon Pan-Pacific expedition, during which euphausiids were sampled using nets, alongside concurrent echosounder data from stations across the NEP. We integrated the lengths and species proportions of euphausiids with echosounder data from daytime transects to identify environmental drivers of species, size, and depth distributions of euphausiids during the expedition. During daytime, euphausiids formed two distinct scattering layers: a contiguous layer around 60m in depth, and a patchy layer of dense aggregations around 226m in depth. The shallower scattering layer was denser towards the south of the survey region, while the deeper scattering layer was denser within the Alaska gyre and closer to the shelf break. Latitudinal differences in euphausiid sizes and species distributions were also evident during the expedition, with larger euphausiids being more abundant further north in the Gulf of Alaska than smaller euphausiids which were more abundant further south and near-shore. Euphausia pacifica and Thysanoessa inspinata dominated euphausiid communities throughout the NEP, while Thysanoessa spinifera, Thysanoessa longipes, and Thysanoessa inermis were more prevalent northwards toward the Gulf of Alaska. These results provide the broadest spatial distribution mapping of euphausiids in the NEP to date, providing new insight into a previously under-sampled region and season.

S04-17295 Oral

Tracking the Atlantification of the Arctic with integrated taxonomy and metabarcoding

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The Arctic is warming at an unprecedented rate, and additionally, relatively warm Atlantic waters, along with associated planktonic biota transported northwards by the West Spitsbergen Current (WSC), penetrate farther into the northern regions of the European Arctic. This intensifies changes observed in the environment, leading to shifts in species distribution ranges and the inflow of new species to the Arctic. All these processes, collectively referred to as the Atlantification of the Arctic, may boost local pelagic biodiversity but also pose a simultaneous threat to naturally occurring communities. Therefore, we aimed to study the influence of Atlantification on zooplankton diversity using the combination of morphology-based taxonomy and metabarcoding, which enables for analyses of entire plankton sample at the same time. For our study area, we selected an oceanic region influenced by WSC and three Svalbard fjords with distinct hydrological characteristics. Zooplankton samples were collected from the epipelagic zone during four consecutive summers of 2019 – 2022, with simultaneous measurements of water physico-chemical properties, and the collection of planktonic protists that were later analyzed with the use of metabarcoding. With morphology based taxonomy, we observed the mixture of arctic, boreal and ubiquitous species which proportions changed between the sampled areas (fjords versus WSC) and across different years. Metabarcoding enabled us to explore the hidden diversity of zooplankton, identify meroplanktonic larvae, and detect species that were either too small or too difficult to be identified through morphological methods. It seems that such an integrated approach can be used in studying processes associated with Atlantification.

S04-17356 Oral

Integrated zooplankton monitoring in a dynamic shallow coastal area

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The shallow well mixed coastal zone of the North Sea is an important feeding and nursery ground for small pelagic fish, with zooplankton being their main source of food. These shallow coastal zones are however poorly covered in current monitoring programmes for zooplankton and pelagic fish which generally take place more offshore. We show the first results of a study aimed at designing a new integrated monitoring programme for zooplankton along a 1000 nm zig-zag transect in the coastal zone of the Dutch North Sea whereby an acoustic fish survey is combined with continuous underway sampling of zooplankton using a Plankton Imager. The continuous sampling was supplemented with WP2 net samples analysed by microscopy, scanning and DNA metabarcoding using COI, 18SV4 and 18SV9 markers. Plankton Imager data revealed distinct trends in zooplankton community composition both perpendicular- and parallel to the shoreline. We show how the insights gained from the different methods complement each other and explain how we used the results to advise on the design the new national North Sea zooplankton monitoring programme for the Netherlands.

S04-17379 Oral

Investigating the Role of Zooplankton in Planktivorous Megafauna Distribution in Qatar: An Integrated Approach Combining Metagenomics, Zooscan Imaging, Classical Taxonomy, and Biochemical methods.

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Understanding the complex interactions between zooplankton and planktivorous megafauna in marine ecosystems is essential for elucidating the dynamics of pelagic ecosystem functioning and resilience. In this study, we present a comprehensive investigation into the role of zooplankton in shaping planktivorous megafauna distribution in Qatar’s offshore seawaters through an integrated approach that combines metagenomics, Zooscan imaging, classical taxonomy, and biochemical methods. Metagenomics approach through eDNA analysis revealed a diverse assemblage of zooplankton species highlighted by classical taxonomy methods, allowing the identification of 65 species and providing insights into potential functional roles. Zooscan imaging enabled rapid identification and quantification of zooplankton groups, facilitating the assessment of their abundance, size distribution and carbon content. In order to quantify the zooplankton biomass and its nutritional quality and potential importance as food source for the planktivorous megafauna, gravimetric methods have been complemented by biochemical analysis of zooplankton biomass, in term of lipids, carbohydrates and proteins. Our findings highlight the significance of zooplankton diversity, abundance, biomass and functional traits in structuring megafauna communities and emphasize the importance of an integrated approach in studying complex ecological interactions. This research contributes to our knowledge of pelagic marine ecosystems and provides valuable insights for the conservation and management of marine biodiversity in the face of ongoing environmental changes.

S04-17387 Oral

CSIRO's Micronekton database including data from 1992 to 2021

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Micronekton are small (~2 -20 cm) free-swimming pelagic organisms. Ecologically, they are the mediators between primary production to higher trophic orders, by providing the trophic link between the mesozooplankton and apex predators. Here we describe CSIRO's micronekton data holdings collected with pelagic trawl nets from 1992 to 2021 from 13 surveys within six areas around southeastern Australia and the Southern and Indian Oceans. Surveys include depth stratified sampling, integrated sampling and some diurnal and seasonal replication and were collected in concert with acoustic and imagery sampling methodologies. Summary data comprise average bulk biomass estimates and species composition by depth, regions and at ocean basin scales. Data are lodged with the CSIRO Data Access Portal (DAP) and provides valuable inputs for ecosystem trophic and carbon models.

S04-17406 Oral (ECOP)

Integrating morphological identification and metabarcoding to understand impacts of climate change on zooplankton communities

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Climate change and anthropogenic activities are influencing zooplankton worldwide, but complexities of zooplankton communities make climate-related shifts difficult to elucidate. Although metrics like total zooplankton biomass can be useful, many responses to stressors vary at the species level. Thus, data on zooplankton community composition are essential to understanding and predicting the impacts of climate change and other stressors on zooplankton and food webs. However, traditional morphological identification methods are limited as some zooplankton species are cryptic and difficult to differentiate, especially at early life stages. Molecular methods such as DNA metabarcoding can identify zooplankton to the species level and detect those that are missed by morphological analysis, often revealing higher diversity than found using traditional methods. Yet amplification bias and other factors make estimating abundances using metabarcoding difficult, whereas morphological analysis can provide accurate counts. Recent studies recommend integrating multiple methods to ascertain a holistic picture of zooplankton community composition. Here, we integrate data from paired zooplankton samples analyzed using two methods: traditional microscope taxonomy and DNA metabarcoding with both broad and targeted markers. Samples were collected during April, July, and September 2018 - 2020 at seven locations in Puget Sound representing a wide range of environmental conditions. We compare how zooplankton communities are structured across varying levels of pH, dissolved oxygen, temperature, salinity, and nutrients. Integrating multiple zooplankton identification methods provides a key approach to understanding how zooplankton communities are influenced by climate change and the impacts these shifts have on marine food webs.

S04-17448 Oral

Epipelagic zooplankton dynamics during International Year of the Salmon winter surveys of the NE Subarctic Pacific (2019, 2020, & 2022)

Joanne K. Breckenridge, Brian P. V. Hunt, Alexei Pinchuk, Moira Galbraith and Evgeny A. **Pakhomov**

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The International Year of the Salmon High Seas Expeditions provided a rare opportunity to better understand winter to early spring zooplankton dynamics across the NE Subarctic Pacific. As part of the Gulf of Alaska Expeditions, bongo samples were collected north of 47.5 °N and east of 147.5 °W in February – March, 2019, and March – April, 2020. For the Pan-Pacific Expedition in 2022, the survey area was expanded eastward to 172 °W and occurred over February – April from four different vessels. To describe zooplankton dynamics, we identified communities using on a cluster analysis of genus abundances from 196 samples and interpreted variation in zooplankton taxon presence and abundance according to life history, behaviour, and regional oceanography. A cluster analysis divided samples largely according to SST, with clusters dominated by subarctic taxa occurring where SST was below 7 °C and clusters with high occurrence of transition zone and/or California Current species occurring with higher SST. The area covered by 'warmwater' clusters varied between years, and was largest in 2020. In addition, a region of low zooplankton abundance was observed in the area of the central Alaska Gyre. We discuss these findings in relation to zooplankton community size structure, biomass, and foraging opportunities for higher trophic levels.

S04-17137 Poster (ECOP)

Presence of hybrids in a highly variable environment

José Martin Pujolar, Cornelia **Jaspers**

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Hybridization of distinct populations or species is an important evolutionary driving force. For invasive species, hybridization can enhance their competitive advantage in the non-native range as a source of adaptive novelty by introgression of selectively favoured alleles. We use single-nucleotide polymorphism (SNP) microarrays to assess genetic diversity and population structure in the invasive ctenophore *Mnemiopsis leidyi* in native habitats along the USA east coast. Hybrids are present at the distribution border of the two linages. However, our data suggests selection against hybrids in stable salinity habitats, while hybrids are selected for where salinity fluctuates. Hybrid populations thriving in spatially and temporally variable environments of the native range, such as Chesapeake Bay, could accelerate the invasion success if translocated. For *M. leidyi*, this is especially relevant as low salinity currently limits its invasion range in western Eurasia. Hybridization status is thus important, but currently disregarded to determine high-risk areas for ballast-water exchange.

S04-17145 Poster

Zooplankton diversity monitoring by metabarcoding in the Southern North Sea

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The diversity and specific composition of zooplankton communities directly affect the structure of marine food webs and are critical for the proper functioning of marine ecosystems. However, the intricate nature of zooplankton, characterized by numerous cryptic and closely related species and subtle morphological differences, as well as a decline in taxonomic expertise for species identification present major obstacles to understanding patterns of plankton biodiversity and ecosystem dynamics. DNA metabarcoding emerges as a valuable and efficient tool for analyzing the biodiversity of natural zooplankton communities. Unlike conventional approaches, metabarcoding has the potential to reveal hidden diversity in marine plankton communities or the presence of non-native species, facilitating rapid detection of ecosystem reorganization. Through sequencing the mitochondrial cytochrome oxidase I (COI) gene from zooplankton samples collected monthly in the Southern North Sea, we performed a comparative analysis with classical morphological methods to provide new insight into the phenology, diversity, and composition of the zooplankton community. In both approaches highest species diversity was detected between June and August, although notable differences were observed especially for species richness. Metabarcoding successfully discriminated between meroplanktonic organisms, including 23 ichthyoplanktonic species, and detected several sibling and cryptic species that were not distinguished by morphological taxonomic analysis. Our results demonstrate the potential of COI metabarcoding for species identification in zooplankton and its importance for ecosystem monitoring by providing valuable insights into community dynamics, hidden diversity, and the presence of key species.

S04-17195 Poster

DNA metabarcoding complementing the assessment of mesozooplankton diversity and seasonal dynamics in Gulf of Finland (Baltic Sea)

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For the past 30 years, mesozooplankton net samples have been collected from the Tallinn Bay (Gulf of Finland, Baltic Sea) at a high frequency of 10-12 samples per season. In 2022, comparable mesozooplankton samples were collected from a single station throughout the season to compare biodiversity and seasonal patterns of dominant taxa using routine sample counting and genetic methods. To further validate the findings, additional data from zooplankton net samples and environmental DNA samples collected from three adjacent harbour areas in the same year were included. This additional information provides supporting evidence and allows for a broader comparison of mesozooplankton diversity in the region. Preliminary analysis of the data revealed conflicting results between traditional identification methods and eDNA analysis. Some species identified through microscopical examination were not detected by metabarcoding, while several species were only detected through genetic analysis. This discrepancy highlights the limitations of relying solely on traditional methods and emphasizes the need for integrating multiple approaches for a comprehensive understanding of biodiversity and plankton dynamics.

S04-17211 Poster

Exploring biodiversity refugia: patterns of meroplankton biodiversity in the vicinity of restored oyster reefs

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Historic declines in European flat oyster reefs have resulted in increased efforts to restore reef habitats, not only to restore the oyster itself, but also to replenish the local biodiversity. Meroplanktonic life stages are important components of reef-associated biodiversity, because they determine the dispersal of benthic species to other habitats. In the German North Sea, the oyster reef restoration is relatively recent and there is so far no assessment on whether effects on the local diversity can be seen (already). In this investigation, we compare habitats close to the restoration site to other habitats further away to evaluate the effect of the reef. To achieve this, we used a case study in the Natura 2000 sites 'Borkum Reef Ground' and 'Sylt Outer Reef' in the German Exclusive Economic Zone in the North Sea. Oyster reefs have so far been restored at Borkum Reef Ground only and not distributed in other regions of the North Sea. We aim to address the following question: Do specific patterns of meroplankton biodiversity develop in the vicinity of the restored reefs, i.e. do the reefs develop refugia and provide habitats for other species? Ship-based zooplankton sampling was conducted in 2022 and 2023 using a net and pump, and meroplankton were identified to species-level using DNA metabarcoding. On the basis of this case study, we present a method for assessing reef-associated biodiversity in a marine restoration measure.

S04-17212 Poster

Exploring the changing dynamics of pelagic metazoan communities in the Beagle Channel: Insights from an integrated research approach

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The Beagle Channel system in Patagonia is currently considered to be in a “pristine” state. However, it is facing growing threads from climate change and anthropogenic pressures. During the Fjordflux cruise (RV Meteor, M179) conducted in early 2021, we sampled the pelagic metazoan community along an east-west transect within the Beagle Channel, encompassing areas with varying degrees of deglaciation and eutrophication. Our primary objective was to analyze biodiversity and abundance using an integrated research approach. Zooplankton was sampled by vertical tows (WP2-, 0-50m) and analyzed using image analysis (abundance, biovolume by ZooScan) and molecular genetic multi-species analysis (COI metabarcoding). Biomass was estimated by converting biovolume to dry weight using established conversion factors for Arctic zooplankton. To capture zooplankton diversity beyond what nets could provide, water from 10 and 30m were analyzed based on environmental DNA COI metabarcoding.
We will discuss how the use of this integrated approach influences the results on the pelagic metazoan diversity along this transect, and how both diversity and abundance/biomass of zooplankton along the Beagle Changes relate to environmental parameters. To gain a comprehensive understanding of the changes occurring in the Beagle Channel, we will compare the current zooplankton community composition and abundance data with data collected during the Victor Hensen cruise conducted in 1994.

S04-17226 Poster (ECOP)

***Calanus* spp. swimming behaviour under laboratory conditions as a proxy for diel vertical migration in the wild.**

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Diel vertical migration (DVM) of zooplankton is, paradoxically, one of the most extensively studied yet least understood behaviours. This paradox arises from the behaviour's complexity, which changes according to community composition, predation pressure, and light conditions. Active acoustics is a method used to investigate DVM offering the advantage of autonomous operation and high temporal resolution in areas difficult to access at the expense of low taxonomical resolution. In-vitro studies are used to investigate species-specific DVM behaviour. However, reproducing complex natural conditions in the laboratory is challenging, and typically, laboratory conditions are oversimplified. Here, we propose to combine active acoustics with in-vitro monitoring of swimming activity to improve our understanding of species-specific DVM behaviour in copepods of the genus *Calanus*. In sub-Arctic and Arctic ecosystems, the *Calanus* genus dominates the zooplankton community and exhibits DVM behaviour. We monitored monthly *Calanus* spp. swimming activity with a TriKinetic locomotor activity monitor under controlled lighting conditions over 9 months. In parallel, we monitored the zooplankton community's DVM behaviour with an Acoustic Zooplankton and Fish Profiler (AZFP) mounted on an autonomous underwater observatory. We identified two swimming behaviours, a negative phototactic response and an asynchronous swimming behaviour and two DVM behaviours, a classical DVM with different amplitude and an asynchronous DVM behaviour. We demonstrated a close relationship between the two behaviour and particularly a that those behaviours are tightly couple to the ambient seasonality in light with aligned seasonal variations. This approach in providing new insights into species-specific DVM behaviour.

S04-17245 Poster

Report on the occurrence of the hydromedusa Odessia maeotica (Ostroumoff, 1896) in the northeastern Atlantic revealed by citizen science and integrative taxonomy

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Gelatinous zooplankton are essential components of healthy ecosystems. Given their characteristic life cycle, ecological aspects and adaptability to a variety of oceanic conditions, these organisms are considered indicators of climate change, having particular advantages relative to other taxa. Citizen science initiatives are becoming increasingly frequent, providing data that are otherwise difficult to collect and interesting results for different taxa worldwide, allowing for example the detection of new occurrences. The ongoing citizen science program GelAvista, running since 2016, gathers data reported by observers on jellyfish occurrences in Portuguese waters, in the northeastern Atlantic. The program has enhanced the knowledge of these organisms, providing data on biodiversity, and the dynamics of their distribution and abundance. Particular sightings of hydromedusae were received through GelAvista for mainland Portugal, close to the Tagus River, in the Lisbon Bay region. The species was morphologically and molecularly identified as Odessia maeotica, comprising its first reported occurrence in the Lisbon Bay. The details on the occurrence of the species are provided and discussed given the current knowledge of the species.

S04-17286 Poster (ECOP)

Patterns of zooplankton species and trait diversity in the Gulf of Alaska from the surface to the abyssopelagic

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The epipelagic zooplankton communities of the Gulf of Alaska have been well characterized by net surveys over the past several decades; however, robust data regarding basic information such as species composition, abundance, and biomass are lacking for the meso-, bathy-, and abyssopelagic zones. In an effort to improve biodiversity estimates and our understanding of deep-sea ecosystems in the Gulf of Alaska, we collected depth-stratified 150-µm and 505-µm mesh samples in July 2019 from the surface to a maximum depth of 4,300 m. Here we present patterns of zooplankton community zonation and diversity along cross-shelf and depth-related environmental gradients. In addition to traditional diversity measures, we also present patterns of functional trait diversity in these zooplankton communities. Changes in functional traits, such as feeding mode and body size, across environmental gradients can provide insight to linkages between species composition and ecosystem properties and function. We compare these estimates of diversity with estimates obtained using molecular approaches from the same cruises. This work complements interdisciplinary efforts to understand the Gulf of Alaska marine ecosystem encompassed within the Northern Gulf of Alaska Long Term Ecological Research (NGA-LTER) and National Oceanic and Atmospheric Administration (NOAA) Ocean Exploration programs and contributes to improved knowledge of zooplankton biodiversity in the North Pacific Ocean.

S04-17316 Poster (ECOP)

Seasonal variation of zooplankton community structure (0-1000 m) in the western Pacific Warm Pool by eDNA metabarcoding

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Understanding the seasonal variation of zooplankton community structure in the western Pacific Warm Pool, the most stable open ocean marine environment on earth, is crucial for predicting the impacts of climate change. However, knowledge of this variation down to the mesopelagic zone remains limited due to difficulties in collecting samples. In this study, we use eDNA metabarcoding to investigate zooplankton community structure across three seasons, from the surface to 1000 m depth. Our findings reveal that seasonal difference of environmental factors was weak but significant in the surface, and it decreased with depth. Zooplankton community structure exhibited seasonal fluctuations at all depths except for 200 m and 1000 m, with stronger variations observed in the epipelagic zone compared to the mesopelagic zone. Specifically, medusae exhibit greater seasonal variation than the overall zooplankton community, whereas copepods did not display significant seasonality. Environment factors exerted a greater influence on the structure of all and medusae communities compared to season and spatial factors, but season was the primary driver of variation in copepod communities. This study provides novel knowledge related to seasonal variations of zooplankton communities in the western Pacific Warm Pool.

S04-17380 Poster **CANCEL not confirmed**

~~**Is there a relationship between sexual size dimorphism and the presence of the myelin sheath in planktonic copepods?**~~

~~Felipe **Gusmão**~~

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~~The myelination of the nervous system is a strong trait in copepods, observed in 50% of calanoid species. The development of a myelin sheath is believed to provide advantages such as increased speed, energy conservation, and improved reaction time to escape predators. Differences between myelinate and amyelinate copepods have been associated with distinct distributions of these groups in the oceans. I propose that the presence/absence of myelin may also have implications for mate searching and copulation, potentially resulting in differences in sexual size dimorphism (SSD – the difference in body size between males and females) between these groups. In this study, I assessed the relationship between the presence/absence of myelin and the SSD in calanoids, utilizing data from 1053 species across 10 amyelinate and 14 myelinate families. I observed that females and males from myelinate species have a significantly greater average body size compared to females and males of amyelinate species, respectively. SSD was greater in amyelinate than in myelinate copepods, both at the species and genus level. Additionally, I observed a similar relationship between male and female body sizes in both groups, with a higher variability in amyelinate copepods. This study establishes a relationship between SSD and myelin in calanoids, with amyelinate copepods displaying greater SSD. It is possible that the greater SSD might be related with the smaller body size of males in amyelinate copepods, which could be an adaptation to compensate for the slower reflexes and speed in amyelinate males, reducing the risk of predation while seeking mates.~~

S04-17385 Poster

A new species of copepod of the Family Pseudiaptomidae from the Great Barrier Reef and discussion of the species diversity and distribution of this family.

Julian **Uribe-Palomino**[1], Chad Walter[4] and Anthony J. Richardson[1,2,3].

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Copepods are some of the most abundant metazoans in aquatic ecosystems, they are highly diverse micro-crustaceans. Some groups of free-living copepods have taken advantage of their environment and have radiated into numerous species as it is the case of the genus *Pseudodiaptomus*, which have their origins in the Eastern Pacific Ocean. Species of this demersal genus is highly euryhaline, typically found in coastal estuarine-marine, from freshwater- hypersaline waters. Here we present a new species described from specimens collected in the Great Barrier Reef and we discuss the geographical distribution of the *Pseudodiaptomus* species found in Australian waters.

Session 5: Zooplankton diets: Advancements in methods, models, and applications

Convenors:
Andreas Novotny (Canada), corresponding
Brian P.V. Hunt (Canada)
Catherine J. Stevens (Canada)
Monika Winder (Sweden)

Zooplankton play a key role in carbon and nutritional transfer from primary producers to fish and in biogeochemical cycling. Essential to resolving these roles is data on zooplankton diets. A variety of methodologies are available for dietary analyses, each with their own set of advantages and disadvantages. Biochemical analyses (fatty acids and stable isotopes) of zooplankton tissues provide integrated information on prey types assimilated (e.g., primary producer types, detritus, trophic group) and can also be used to assign trophic level. Traditional microscopic gut content analysis can quantity and identify taxonomic prey individual, however, it is feasible only for large individuals and biased toward hard-bodied dietary items. DNA metabarcoding of zooplankton gut contents is a highly promising technique that can provide species-specific dietary information, including frequently-overlooked gelatinous and soft-bodied microzooplankton prey. Despite their potential, DNA gut sequence data can be difficult to interpret due to primer biases, contamination with host material, the prevalence of parasitic sequences, and gene copy number. Questions remain as to the comparability of data generated using different analytical approaches, how data from different analysis types can be combined to enhance food web interpretation, and the wider applications of these approaches to support food web model parameterization. In this session, we welcome submissions for zooplankton dietary studies utilizing all available methods, emphasizing novel approaches, including molecular techniques, compound specific isotopes, integration of multiple approaches, modelling and wider ecological applications of zooplankton dietary information.

S05-17092 Oral (ECOP)

Trophic interaction and vertical migration as a mechanism for downward transport of C to the deep ocean

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The vertical migration of zooplankton groups is part of the active transport of Carbon (C) in the biological pump, knowledge about the relevance of this transport has been limited to the mesopelagic zone of the water column. This project aims to determine the contribution of the mechanism of the trophic ladder and vertical migration to promote the vertical transport of organic carbon to the deep ocean. The study area is the Eastern South Pacific Ocean (Chile), which is characterized by being an upwelling system in the north (LowpHox-II, summer 2018) and south-central Chile (MAPUCHE, summer 2023), with the presence of the permanent and intense OMZ from 25 to 400 m deep. To assess the contribution of the active transport of C, we will focus on gathering data related to prey-predator interactions and the vertical migrations patterns of mesozooplankton biomass by size classes (MultiNet) and micronekton (MOCNESS). Additionally, we will integrate the trophic position (TP) and the isotopic niche from measurements of the $d^{15}N$ and $d^{13}C$ stable isotopes in specific compounds (amino acids). This project aims to provide evidence on the trophic interaction between different strata of the water column (0 – 1000 m) associated with the daily vertical migrations that originate the trophic ladder ultimately facilitating the active vertical transport of carbon towards the deep ocean.

S05-17221 Oral (ECOP)

Zooplankton feeding selectivity determines the structure of a quantitative food web model supported by DNA dietary data.

Andreas **Novotny**[1], Baptiste Serandour[2], Susanne Kortsch[3,4], Benoit Gauzens[5,6], Kinlan M.G. Jan[2], and Monika Winder[2]

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Models that estimate rates of energy flow in complex food webs often fail to account for species-specific prey selectivity of diverse consumer guilds. While DNA metabarcoding is increasingly used for dietary studies, its application for food web modeling has been limited due to methodological biases. Here we demonstrate how data from dietary metabarcoding studies of zooplankton can be used to assess energy fluxes in a pelagic resource-consumer network, by calculating prey selectivity indices. We show that zooplankton prey selectivity together with temporal match-mismatch in growth cycles together shapes the food web dynamics and that cyanobacteria are the main source of primary production in the investigated coastal pelagic food web. The latter challenges the common assumption that cyanobacteria are not supporting food web productivity, a result that is increasingly relevant as global warming promotes cyanobacteria dominance. While this study provides a method for how DNA metabarcoding can be used to quantify energy fluxes in a marine food web, the approach presented here can easily be extended to other ecosystems.

S05-17238 Oral (ECOP)

Seasonal variability in prey sources for zooplankton revealed by fatty acid- and stable isotope-based diet estimation

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Zooplankton form a critical link between primary producers and higher trophic levels, but this connection is complex and composed of many different individual linkages. Different taxa are capable of feeding on distinct components of the prey field, resulting in unique trophic connections to specific zooplankton. In addition, the prey sources consumed by specific zooplankton shift seasonally in response to changing prey availability. The result is a dynamic relationship between the food web base and zooplankton consumers, with important consequences for fish, seabirds, and whales. We quantified the dietary sources of ten common zooplankton taxa at a temperate coastal site in the Strait of Georgia, Canada at several points in a seasonal cycle (May, July, September, November, January) using fatty acid and stable isotope trophic markers. Dietary sources included mixed zooplankton (250-500 µm) and size fractioned particulate organic matter (POM), to characterize the contribution of different sized components to zooplankton diets. Zooplankton taxa were supported by different prey sources, but the dominant prey source of each species changed throughout the season, highlighting the importance of seasonal shifts. At times, pico-POM (0.7-3 µm) made important contributions (> 50%) to Limacina, Metridia, Euphausia, Eucalanus, and Primno diets. Micro-POM (>20 µm) was an important diet item for Eucalanus, Calanus, and Cyphocaris. Widespread seasonal diet shifts resulted in strong changes in the trophic markers and nutritional quality of zooplankton. Such variability is important to account for, particularly during under-sampled periods like winter.

S05-17241 Oral (ECOP)

Case study of Salpa aspera in the mesopelagic food web of the NW Atlantic: Integrative analysis using metabarcoding of diets and eDNA, image analysis, and hydrography

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Gelatinous zooplankton are important grazers in mesopelagic food webs, although many questions remain about their diet and trophic impacts. Salps (Tunicata) are efficient filter feeders; many species exhibit extensive vertical migration behaviors that may result in transport of organic material and carbon between the surface and deep waters. We report results from a field expedition on the R/V Armstrong (AR-43) in March 2020 in the NE Atlantic Ocean. Salps (solitary and aggregate forms) were collected in vertically stratified tows of a 10-m^2 MOCNESS. DNA metabarcoding of dissected gut contents used V4 and V9 hypervariable regions of 18S rRNA to detect a broad taxonomic range of consumed prey and examine trophic pathways of pelagic food webs. Metabarcoding of environmental DNA (eDNA) and IFCB cell counts used water samples collected with vertical CTD tows at the same stations. Diel vertical distribution patterns of solitary and aggregate forms of S. aspera were determined from in situ shadowgraph imaging (ISIIS). Multivariate statistical analysis was used to compare prey composition for salps collected from 4 depth strata at 5 stations. Based on comparative analysis of 18S V9 sequences from gut contents, eDNA and cell counts, S. aspera prey content differed from ambient water column composition in the same depth zones. The integration of metabarcoding of S. aspera gut contents and eDNA, cell counts, and imagery allowed new understanding of trophic relationships of S. aspera and new appreciation for impacts of salps on vertical transport of organic material in pelagic ecosystems.

S05-17270 Oral

Chaetognath gut DNA: Development of metabarcoding techniques to determine diet

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Chaetognaths are abundant members of the global mesozooplankton community and occupy a central position in marine food webs. Chaetognaths can exert significant predation pressure on primary consumers, e.g., copepods, and they serve as prey for other zooplankton and fish. However, new evidence questions the extent to which chaetognaths are obligate carnivores, and the strength of the trophic link between chaetognaths and crustaceans. Recent studies have demonstrated that chaetognaths can directly ingest phytoplankton, detritus, and hydrozoans. In this study, we used metabarcoding to determine chaetognath diet, which has the capacity to identify prey items to the species level. DNA was extracted from four chaetognath species (Eukrohnia hamata, Pseudosagitta scrippsae, Parasagitta euneritica, P. elegans) collected between 2019 and 2023 in the Chukchi Sea, along Line P, off the west coast of Vancouver Island, and in the Strait of Georgia (BC, Canada). Gut DNA was sequenced using primers that amplify the V4 region of the 18S gene in most types of mesozooplankton but not chaetognaths, thus eliminating the need for blocking primers. Both crustacean and gelatinous zooplankton sequences were found in the guts of most chaetognaths, with E. hamata having the highest proportion of gelatinous sequences. Sequences derived from hydrozoans were the most common type of gelatinous DNA in the guts of all species, while sequences from appendicularians, doliolids, and ctenophores occurred less frequently and in lower relative amounts. Understanding trophic interactions among gelatinous organisms is of high importance since the NE Pacific Ocean increasingly experiences warming events and blooms of gelatinous species.

S05-17278 Oral (ECOP)

Dietary effects on reproductive traits, development, and fatty acids in cladocerans and calanoid copepods.

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Herbivorous zooplankton play an important role in pelagic systems as grazers of phytoplankton and as a food source for higher trophic levels. In freshwater lakes, cladocerans and calanoid copepods are the most important pelagic herbivores, both in terms of numbers and grazing impact. Although much has been learned over the past two decades about the dietary requirements of freshwater zooplankton in terms of quantity and qualitative composition, recent comparative studies of zooplankton and their diets have yielded contrasting results in terms of dietary dependence, demonstrating that the often-repeated principle "you are what you eat" seems to apply only in part. Here we used a fatty acid approach to investigate different diets and their effects on reproductive and life-history responses in both Daphnia longispina and Eudiaptomus graciloides. Dietary fatty acid composition was generally reflected in consumer tissues in both grazers, and the nutritional quality of the diet affected zooplankton fitness and reproductive success differently depending on grazer feeding mode. However, a differential accumulation of PUFAs was observed between cladocerans and calanoid copepods, and mismatches in some fatty acids suggested a possible enzymatic modification of dietary fatty acids adopted to cope biochemical deficiencies of the diets. As the ability of freshwater zooplankton to synthesise and/or biochemically convert FAs is still unresolved and highly controversial, the integration of different approaches and zooplankton dietary information is needed to improve our understanding of the feeding ecology of freshwater zooplankton and how this affects trophic interactions and plankton dynamics under changing environmental conditions and resource availability.

S05-17280 Oral (ECOP)

Unravelling marine zooplankton food webs: combining CRISPR with gut DNA metabarcoding to understand zooplankton trophodynamics

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DNA metabarcoding of zooplankton gut contents has become the principal molecular technique used by marine ecologists to determine the full range of zooplankton prey taxa. However, where eukaryotes feed on other eukaryotes, the use of 18S rRNA generates the preferential amplification of predator DNA, whereby “fresh” predator DNA completely overwhelms partially-digested prey DNA. Existing approaches to reduce this non-target amplification include gut dissections, PCR clamps, blocking primers and restriction enzymes. Gut dissections are intensely time-consuming and risky with valuable specimens, and predator DNA may still dominate sequences. Blocking primers may co-block prey species and therefore conceal important prey taxa.

CRISPR technology was introduced in 2012 and together with Cas9 nuclease, has been hailed as the “simplest, most versatile and precise method of genetic manipulation”, and a revolutionary way to edit genes and DNA.

Here we present a novel approach to molecular gut-content analysis, applying a recent CRISPR-based methodology, CRISPR-Cas9 Selective Amplicon Sequencing (CCSAS) to whole zooplankton from the Strait of Georgia, British Columbia, Canada.
Results indicate that the CCSAS method yielded a higher proportion of diet reads than previous tests without CRISPR. CCSAS liberated degraded DNA fragments from predator amplification pressure and generated an increased diversity of prey DNA. In addition, CCSAS resulted in an increased proportion of symbiont, fungal and terrestrial DNA, allowing questions to be answered on other facets of the microbiome. We present seasonally variable mesozooplankton diet data, and in addition we investigate intraspecies diet variability through the extraction of DNA from individual zooplankton specimens.

S05-17308 Oral

Community composition, functional traits, and trophic structure of zooplankton size fractions across an oligotrophic eutrophic gradient

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The trophic structure of zooplankton food webs is a key determinant of energy transfer efficiency between phytoplankton and higher trophic levels. Food chain length, the number of trophic levels across a food web, is inversely correlated with energy transfer efficiency (TE) and factors that govern the shortening or lengthening of the food chain are therefore critical to food web production. In the case of zooplankton, phytoplankton size structure is considered to be an important variable determining TE, with inefficient grazing of small (pico) sized phytoplankton in oligotrophic systems expected to favour longer food chains while large phytoplankton (micro), which dominate in eutrophic systems, are expect to favour short, more efficient food webs. Understanding of the length of zooplankton food chains has been significantly advanced by stable isotope analysis of size fractions. Size structured approaches have the advantage of simplifying complex zooplankton communities, however, at the expense of information on functional ecology. Generating species composition and associated functional trait data for zooplankton size classes therefore offers a valuable complement to trophic level that can inform trophic pathways and trophic mechanisms controlling TE. In this paper we combine size structured stable isotope and taxonomic analyses for zooplankton samples collected from pelagic ecosystems spanning an oligotrophic-eutrophic food web gradient spanning temperate British Columbia, Mediterranean, sub–tropical South Pacific, and the Southern Ocean. Using this combined approach, we critically assess the functional ecology of zooplankton communities and how this relates to phytoplankton production and food chain length.

S05-17331 Oral

Fine scale trophic interactions and niche differentiation among conspecific mysids in the St. Lawrence Estuary, Canada

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Mysids are a crucial component in estuarine ecosystems, channelling energy through the food web, supporting the nursery function for crustaceans and fishes. In the St. Lawrence Estuary two sympatric mysid species, Mysis stenolepis and Neomysis americana co-occur. The latter a cryptic species complex is composed of two lineages that show spatial segregation along the estuary. We studied feeding strategies and niches among species and within the cryptic species complex to determine if coexistence is achieved by food niche partitioning, that might help to reduce inter- and intraspecific competition. We monitored feeding using a multi-marker approach, including fatty acids (FA), stable isotopes (SI) and specific qPCR on gut content. Interspecific differences were confirmed, as the trophic position of M. stenolepis was significantly higher than that of N. americana. Based on FA and SI, Neomysis americana showed a high plasticity in feeding strategies switching from herbivory (downstream) to omnivory (upstream; detritus, the copepod Eurytemora affinis) depending on prey availability, which confirms its opportunistic feeding behaviour. More interestingly, similar feeding niches were found between the two lineages, exposed to the same food supply in a given habitat. The novel qPCR approach to determine the contribution of a two cryptic copepod prey species in the diet revealed that N. americana exploited E. affinis and E. carolleae, whereas M. stenolepis exclusively fed on E. affinis. Our study demonstrates fine scale trophic interactions could only be assessed by a multi-marker approach, integrating multiple time scales to enhance our understanding of trophodynamics in a highly dynamic estuary.

S05-17375 Oral

Feeding behavior responses of the small copepod, Paracalanus Parvus, to toxic algae at different concentrations

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The feeding relationship between copepods and phytoplankton has immense ecological significance. This study investigated the feeding behavior of copepods by studying the feeding selectivity of Paracalanus parvus, using a high-speed camera. The feeding behavior of P. parvus separately fed on three algae was studied at five different concentrations. The feeding behavior showing as the beating frequency (BF), beating time (BT), and rejection behavior, were analyzed. The average BT and BF of P. parvus fed on toxic algae were significantly lower than those of copepods fed on nontoxic algae, indicating that the toxic algae negatively affected their feeding behavior. There were no significant differences in feed rejection among the three algae, indicating that the rejection behavior was insignificant in the early period (within 20 min) of feeding on toxic algae. The feeding behavior was inhibited when the concentration reached 250 cells/mL, in which the BT was initially affected at increasing concentrations followed by the BF. Analysis of the average BFs revealed that P. parvus was more significantly affected by P. minimum than by A. minutum. The BF of copepods fed on P. minimum was significantly lower than that of copepods fed on A. minutum at 250–500 cells/mL but was not significantly different from that at 1000 cells/mL. This indicated that the inhibitory effect of P. minutum on the feeding behavior was more significant at concentrations observed at the onset of red tide blooms than in advanced red tides. This study demonstrates that toxic dinoflagellates alter the feeding behavior of copepods.

S05-17378 Oral (ECOP)

Exploring seasonal differences in North Atlantic mesopelagic zooplankton communities utilizing carbon CSIA

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Compound specific stable isotope analysis of carbon is a powerful ecological tool. It has often been utilized to visualize carbon flow through larger nekton communities in coral reefs and coastal habitats. However, the zooplankton community is often lumped into size classes or utilized as a proxy for phytoplankton end members. In the mesopelagic, the zooplankton communities are often very dense and diverse. Understanding carbon flow through these communities is vital for understanding active carbon transport given the diel vertical migration preformed by many species and importance of the fecal pellets of groups such as salps. One barrier to the utilization of CSIA within zooplankton communities is the lack of end member signatures in the literature. In my work, I utilized literature values for several diatom and dinoflagellate species local to the Northwest Atlantic as well as a range of heterotrophic bacteria. Cyanobacteria were not well represented in literature data, so I acquired cultures of several strains of both Synechococcus and Prochlorococcus to establish the signature of this ecologically important phyla. In order to get a more nuanced view of the zooplankton community, I sorted MOCNESS samples into several copepod, euphausiid, amphipod, salp, chaetognath, and ostracod genera groups. My samples were collected on several cruises across multiple seasons in the Northwest and Northeast Atlantic. I found there to be decent grouping among individuals from the same genera, but this varied with the seasons. These results give us foundational knowledge about how the zooplankton in the mesopelagic are utilizing carbon sources.

S05-17058 Poster (ECOP)

Tracking spatial and temporal pattern in zooplankton trophic dynamics in the eutrophic Elbe estuary (Germany): A multiple stable isotope approach

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The Elbe River is a tidal estuary in northern Germany which is heavily impacted by excessive load of particulate organic matter (POM) due to intensive agricultural land use and deepening of the riverbed. In general, estuaries are characterized by strong physical and biochemical gradients that effect the planktonic food web in terms of production and trophic transfer of organic matter. Here, we applied an analysis of $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ stable isotopes to define seasonal and spatial variation in the trophic structures as well as to detect the primary carbon source of the food web. We collected POM, microphytobenthos and different species of meso- and macrozooplankton including ichthyoplankton at five stations along the entire estuary in 2022. Trophic niches and feeding preferences of zooplankton species were defined using Stable Isotope Bayesian Ellipses in R (SIBER) and MixSIAR models, respectively. Our results show distinct spatial variations in the stable isotope compositions of primary producers and zooplankton species related to the salinity gradient. Organisms that were collected upstream were depleted in $\delta^{13}C$ and $\delta^{34}S$ and enriched in $\delta^{15}N$ ratios compared to those from sites close to the river mouth, indicating a conservative mixing of riverine and coastal POM sources. The trophic niches of the planktonic groups showed a high degree of overlap among them, which was validated by their large tendency of omnivorous feeding behavior. This study demonstrate the capability of the Elbe planktonic food web to buffer hydrological alterations related to human disturbance and seasonality by omnivorous feeding strategies.

Session 6: Applications of time series to track changes in zooplankton communities and impacts on ecosystem structure and function

Convenors:
Todd O'Brien (USA), corresponding
Catherine Johnson (Canada)
Jasmin Renz (Germany)

Invited Speakers:
Catherine Johnson (Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth, NS, Canada)
Lavenia Ratnarajah (Institute for Marine and Antarctic Studies (IMAS), Australia)
Anthony Richardson (CSIRO, Australia)

Zooplankton are sensitive indicators of change in aquatic ecosystems, and their abundance and composition are vulnerable to the rapidly changing conditions observed in many marine and freshwater systems worldwide. As major primary consumers and predators, zooplankton play a significant role in the transfer of energy and material across aquatic food webs, and changes in their abundance and composition can impact ecosystem structure and function. Changes can be characterized and tracked from a variety of different perspectives, including species relative abundance and trait composition, diversity metrics and other indices, phenology shifts, etc. This session will focus on using time series to identify and understand zooplankton population and community changes, relationships to environmental and ecological changes, and potential effects on higher trophic levels. This theme session welcomes contributions using a broad variety of approaches related to the development, integration and application of methods for pelagic habitat assessment, with particular focus on the following topics: 1) Empirical analyses of time series and the development of indicators and indices to track changes in the ecosystem; 2) Assessment of the pelagic habitat status using indicators of the plankton community or its components; 3) Numerical and statistical modeling studies, genetic methods and other new methodologies for the assessment of the ecosystem status; 4) Incorporation or discrimination of climate-driven and anthropogenic responses for the assessment of ecosystem state.

S06-17116 Invited (ECOP)

Monitoring and modelling marine zooplankton in a changing climate

Lavenia **Ratnarajah**[1,2], Rana Abu-Alhaija[3], Angus Atkinson[4], Sonia Batten[5], Nicholas J Bax[6], Kim S. Bernard[7], Gabrielle Canonico[8], Astrid Cornils[9], Jason D. Everett[10,11,12], Maria Grigoratou[13], Nurul Huda Ahmad Ishak[14,15], David Johns[16], Fabien Lombard[17,18,19], Erik Muxagata[20], Clare Ostle[21], Sophie Pitois[22], Anthony J. Richardson[10,11], Katrin Schmidt[23], Lars Stemmann[17], Kerrie M. Swadling[24], Guang Yang[25], and Lidia Yebra[26]

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Zooplankton are major consumers of phytoplankton primary production and represent a critical link for energy and matter transfer to higher trophic levels and play an important role in global biogeochemical cycles. We undertook a global review to investigate the impacts of ocean warming on zooplankton phenology, range, and body size, and assess the implications to the biological carbon pump and interactions with higher trophic levels. Whilst ocean warming is predicted to result in changes in phenology, reduced size and poleward range shifts, our review highlighted some contrasting response observed between the northern and southern hemispheres. For example, copepod and Antarctic krill in the Southern Ocean are increasing in size, and some species are not migrating polewards. Impacts of ocean warming on the biological carbon pump are unclear as local/regional environmental conditions coupled with changing zooplankton dynamic sets the recycling and export potential. However, there is substantial evidence on how changes in zooplankton dynamics are negatively impacting higher trophic levels, including commercial fisheries. We highlight that despite identifying 168 long-term zooplankton monitoring programmes and CPR surveys undertaken in 6 oceanic regions, only 19% of these programmes had freely available data. This significantly hampers our ability to gain greater insight into how zooplankton are responding to a changing ocean. Geographic coverage is lacking in regions around Asia, South America, Africa and equatorial waters. To improve zooplankton observation for the benefit of monitoring zooplankton populations and modelling future scenarios, we designed an integrated sampling approach that combines traditional and novel techniques.

S06-17225 Invited

Detection and assessment of community changes in a trans-North Atlantic comparison of zooplankton time series

Catherine L. **Johnson**[1], Todd D. O'Brien[2], Dafne Eerkes-Medrano[3], on behalf of all the ICES-WGZE study participants

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The collective zooplankton monitoring and sampling efforts sustained by researchers associated with the ICES Working Group on Zooplankton Ecology (WGZE) yield a basin-wide, North Atlantic compilation of over 100 zooplankton time series. These time series, ranging from 15 to 50+ years in length, differ in sampling gear (e.g., net type and mesh size), sampling frequency (e.g., monthly, weekly, one-season-only), taxonomic resolution, and processing methodology. While direct quantitative comparisons would be extremely complicated at best, spatially coherent changes and patterns in the magnitude and direction of trends are evident within and between these time series. Building on comparisons of zooplankton bulk properties such as "total biomass" and "total copepods," WGZE investigators are examining community changes using a rank-based approach to detect and visualize relative dominance changes within and across North Atlantic copepod communities. For example, in some regions dominance structure within the copepod community has recently shifted, with historically dominant species replaced in dominance by new species. These changes can be hidden when looking only at total abundances, since a measured increase in total copepod abundance does not identify whether one species group has increased/decreased relative to another (e.g., an increase of smaller species relative to larger species). This approach, focusing on community composition, helps us identify changes in ecosystem structure and function and to relate these to human and environmental pressures. This talk summarizes the ongoing work, challenges and approaches used by the ICES WGZE North Atlantic zooplankton community study.

S06-17327 Invited

Global zooplankton trends over the past 80 years

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Zooplankton are the primary link between marine phytoplankton and higher trophic levels. Although there is evidence of a long-term decline in phytoplankton biomass over the past century in response to climate change, we do not know how zooplankton has responded, primarily because of the many ways zooplankton biomass is collected (e.g., vertical, horizontal, oblique net tows using mesh of different sizes) and measured (e.g., wet weight, dry weight, displacement volume). Here we use generalised mixed models to adjust for these collection and measurement differences and thus standardise several hundred thousand measurements of zooplankton biomass collected from ship-board measurements and time series. We analyse the long-term trends of zooplankton biomass across Longhurst provinces globally. We also analyse whether large-scale climate phenomena such as El Niño Southern Oscillation and the Pacific Decadal Oscillation are driving changes in zooplankton biomass. The response of zooplankton biomass over time will provide insights into how the carrying capacity of the oceans is changing, and the large-scale relationship between phytoplankton and zooplankton biomass.

S06-17031 Oral (ECOP)

Effects of climate change induced dominance shifts in zooplankton community composition on the carbon cycle

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Anthropogenically induced climate change has affected the marine environment by ocean warming, acidification, changed nutrient loads and changed salinities. Due to its long water exchange time, shallow depth and low salinity, the effects in the Baltic Sea happen earlier and stronger than in other seas. For instance, the Baltic Sea has already faced temperature and salinity fluctuations that most other seas will only experience in the future. These changes alter zooplankton communities in terms of community composition or functional diversity with a reported shift towards smaller organisms and a loss of zooplankton biomass. Ultimately, changes in zooplankton community composition can alter the functioning of the biological carbon pump in terms of carbon uptake, transport and export as the potential decrease in zooplankton size could weaken the transport of organic material to the seafloor. In this study, zooplankton data from the long-term monitoring site Tvärminne Storfjärden in the Gulf of Finland, northern Baltic Sea, spanning 55 years, are analysed to identify changes in zooplankton community composition and model future developments. The results show a decline in the abundance of larger zooplankton species and a concurrent increase of smaller zooplankton species due to rising temperatures and decreasing salinity. Based on these results experiments will be conducted to identify direct (e.g. respiration rates, carbon export in form of excretion and CH_4) as well as indirect effects (e.g. grazing pressure) of the changed community structure on the carbon cycle.

S06-17045 Oral (ECOP)

Changes in zooplankton communities from the North Pacific Continuous Plankton Recorder (CPR) Survey

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Here we present over 20 years of CPR data collected in the North Pacific. Our investigation spans the Gulf of Alaska and Northeast Pacific regions, utilizing trait-based zooplankton indices to elucidate the observed changes and their potential ecological implications. Furthermore, we employ a zooplankton community temperature index (CTI) to assess the potential impact of temperature on these trends. The study area experienced a prolonged marine heat wave during the last decade with above average temperatures for eight years.

In 2022, copepod species typically associated with warmer waters exhibited a decline in abundance, both in the offshore and shelf regions surrounding British Columbia and in the Gulf of Alaska. We also observed a notable increase in the mean copepod size, an indicator of community composition. These findings underscore the influence of temperature on zooplankton communities, and our analyses reveal higher CTI values during heat wave years, reinforcing the temperature-driven nature of these changes.

The zooplankton recorded in 2022 demonstrate a return to more typical sub-arctic/temperate community structures coincident with the end of the anomalously warm period. This shift towards average values of large copepod abundance in both shelf and offshore regions could influence food web dynamics, as these copepods store greater lipid reserves for overwinter survival. These findings shed light on the intricate interplay between climate induced perturbations and the resilience of marine ecosystems, offering valuable insights into the future trajectory of North Pacific zooplankton communities.

S06-17066 Oral

A pyrosome irruption in the California Current Ecosystem in the context of the preceding 7 decades: a tipping point crossed or a recurrent phenomenon?

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An outbreak of pyrosomes (generally reported as Pyrosoma atlanticum) in the California Current Ecosystem (CCE) in 2014 coincided approximately with the onset of large-scale warm anomalies in the Northeast Pacific. In most regions of the CCE, pyrosomes have persisted since that time, at varying levels of abundance. The widespread occurrence of this conspicuous, macroscopic zooplankter has altered the prey field to zooplanktivores, perhaps affected grazing pressure and elemental export, and has drawn the attention of the general public. The question has arisen whether the outbreak of this pelagic tunicate is unprecedented in this oceanic region. We draw on timeseries sampling by the California Current Ecosystem Long-Term Ecological Research Site (CCE-LTER, 19 years) and by CalCOFI (75 years), to understand both the recent and historical timing of pyrosome outbreaks and their prevalence in both Southern and Central California waters. We illustrate reduced pyrosome biomass in coastal upwelling waters. We use both underwater imaging by UVP5 as well as extensive vertically stratified MOCNESS tows on CCE-LTER process cruises to test for size-dependent Diel Vertical Migration (DVM). We find the clearest DVM responses consistently expressed by colonies > 30 mm in length. We will address the evidence for long-term, secular changes in pyrosome occurrence in this Eastern Boundary Current upwelling province.

S06-17104 Oral

Zooplankton diversity and climate-driven range shifts on the NW Atlantic continental shelf: Metabarcoding analysis of time-series ecosystem monitoring

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Temporal and spatial patterns of species diversity of the zooplankton assemblage of the Northeast US (NEUS) continental shelf reflect the impacts of climate variation over recent decades. This ecosystem has been surveyed for fisheries assessments and pelagic diversity for many decades. Zooplankton samples have been collected and preserved for genetic analysis during Ecosystem Monitoring (EcoMon) Surveys by NOAA Northeast Fisheries Science Center (NEFSC) from 2000 to the present. A selection of samples collected from several NEUS regions during May-June of 2002-2012 was analyzed using DNA metabarcoding of a short region of mitochondrial Cytochrome Oxidase I (COI). Additional samples collected during 2003, 2013, and 2019 were analyzed for both COI and mitochondrial 16S rRNA. Identification of species based on metabarcoding used the MetaZooGene Atlas and Database https://metazoogene.org/mzgdb/, which provides reference DNA sequences for marine species by taxonomic group and ocean region. Time-series analysis of COI and 16S rRNA sequence numbers for selected taxonomic groups and species of zooplankton allowed quantitative description and statistical analysis of variation in biodiversity over time (seasons, years, decades) and space (ocean regions). Metabarcoding using both COI and 16S gene regions showed changes in species diversity of the zooplankton assemblage resulting from latitudinal shifts in key species over time and/or appearance of non-indigenous species. Our research provides information and insights for consideration of inclusion and integration of DNA metabarcoding of time-series monitoring samples for assessment of marine ecosystems and detection of impacts of climate change.

S06-17115 Oral

Northward distribution shift of Neocalanus plumchrus in the western-central Pacific Ocean during almost two decades

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The transition and subarctic regions of the western and central North Pacific Ocean are one of the high fisheries production areas in the global ocean. Recently, the pelagic plankton ecosystem might be affected by the rising of water temperatures, the occurrence of marine heatwaves, and meandering currents. This study investigated the long-term distribution changes of the large copepod Neocalanus plumchrus in early summer, which is an important prey for pelagic fish, based on zooplankton samples collected in the transition regions from the coast to approximately 4,500 km offshore to the east, spanning from 2004 to 2022. Over a period of nearly 20 years, the southern limit of N. plumchrus has shifted northward by approximately 1.5 degrees of latitude. This northward shift speed observed in N. plumchrus was faster than those reported from observed and estimated values by numerical model approach for mesozooplankton species in previous studies. Also, numerical model approaches showed that the northward shift was more rapid than that predicted by the water temperature rising from 2004 to 2022. These results suggest that recent changes in the ocean environment have had a serious negative effect on the distribution and abundance of N. plumchrus, leading to a continuous northward shift.

S06-17125 Oral

Timeseries, indices & tools lead to understanding

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The Integrated Marine Observing System (IMOS) network of National Reference Stations (NRS) provides quality-controlled data on temporal and seasonal trends in plankton from around Australia, supporting both scientific research and informing management strategies leading to policy change. Time-series of plankton and environmental data can be used to understand how biological diversity and biomass respond to changes in associated environmental and biogeochemical conditions, and thus how ecosystems are shifting or adapting to natural and anthropogenic stressors. After 15 years of sampling, these multi-variate datasets are now large and complex and better tools are needed to enable access, visualisation and interpretation of biological data for an increasingly broad user base.

We created the IMOS Biological Ocean Observer (BOO) an interactive web page to improve data accessibility and interoperability across a range of users from skilled analysts to the general public. Here we provide three examples from BOO of current usage including i) direct input into State of the Environment reporting, improving management decisions that can influence policy ii) teaching applications, real examples with annotated code for use in Australian undergraduate and postgraduate courses in marine and environmental science and iii) hypotheses testing, exploring responses of marine plankton communities to increasing ocean temperatures in a global warming hotspot in South East Tasmania. We show that by visualising trends in indices, including Essential Ocean Variables, against a broad range of associated physical and chemical parameters or through time we can quickly understand how planktonic communities are changing.

S06-17151 Oral

Early warning indicators of shifts in the plankton assemblage of the Cabo Frio Upwelling System

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Ocean productivity fuels the functioning of marine ecosystems, lowers atmospheric carbon dioxide and shapes biodiversity distribution in the seas - three fundamental elements of the blue economy. Globally or locally, plankton contributes to ocean productivity, cascading up to fishes, mammals and birds. Therefore, we aim to monitor the spatial and temporal variability in plankton abundance over the last decades in a fixed station in the Cabo Frio Upwelling System (CFUS). This wind-driven upwelling ecosystem is regionally responsible for the sustainable exploitation of sardines and anchovies, among others, by traditional fishermen in a Marine Protected Area inside CFUS. The study hypothesizes that the decadal change in temperature and salinity in CFUS might lead to a planktonic disruption and significant shifts in the ecosystem functioning. The study was carried out at a fixed station on Cabo Frio Island (23°S - 042.01°W) as part of the Long-Term Ecological Research (LTER). Weekly estimates of phytoplankton and zooplankton were obtained from reanalysis in a FlowCAM cytometer and the images were processed in the Ecotaxa platform (FlowCam H2020 EU Mission Atlantic Project). Monthly averages of the different phytoplankton and zooplankton populations were correlated to the temporal change in temperature and salinity. The most significant ecosystem shift observed over the decades was the replacement of a diatom-dominant ecosystem by a dinoflagellate-dominant one. Dinoflagellate species, unlike diatoms, are specialists in ecosystems with higher salinity and temperature and low concentrations of nutrients. There was a cascade effect in the food web affecting the opportunistic zooplankton groups - copepods and cladocerans.

S06-17165 Oral

Long-term continuous plankton recorder data and joint species distribution models reveal changes in zooplankton communities in the Southern Ocean

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The Southern Ocean is a highly productive and dynamic system supporting diverse communities of zooplankton. The Antarctic research community has been monitoring zooplankton using the standardised continuous plankton recorder (CPR) to collect assemblage data for many decades. To date the bulk of the analysis on CPR data has focussed on krill. In this study we use 20 years of CPR data with joint species distributions models to study the entire species assemblage and establish where, when and what species have changed in prevalence and abundance. Specifically, we use hierarchical modelling of species communities to model the presence/absence and abundance of each species as well as total zooplankton abundance and species richness in relation to environmental and climate variables. We demonstrate that the distribution of zooplankton and community structure is highly complex, patchy, and susceptible to rapid change due to rising sea surface temperatures, changing ocean currents, and the southern annular mode. We show that while many species have increased in prevalence and abundance, several species have declined. The ecological consequences for this change in community structure is unknown. This study highlights the importance of having long-term monitoring data using the standardised methods such as the CPR. The results from this study will be used to further explore which species and where future monitoring efforts should focus to maximise the efficiency of zooplankton monitoring but it needs to be spatially balanced across the Southern Ocean to enable the ability to detect future change.

S06-17182 Oral (ECOP)

Interannual variability of the biomass of Lake Victoria's decapod zooplankton Caridina nilotica (Atyidae) determined from acoustic survey and a new acoustic Target Strength.

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Caridina nilotica is a Nile-endemic freshwater decapod zooplankton in Lake Victoria (East Africa), the world's second-largest freshwater lake. It feeds on the eutrophication driven and increasingly available phytoplankton and detritus, attaining a maximum size of 25 mm after 120 days. Lake Victoria is the site of capture-fisheries that are vital for regional food security and economic development. Caridina is an important food for juvenile Nile perch and for some cichlids, so plays an important role in the lake's fisheries ecosystem. However, knowledge of Caridina biomass variability is limited, hampering progress towards ecosystem-based fisheries management. For the past ca. 20 years, annual fisheries-acoustic surveys have been conducted, including efforts to determine Caridina biomass by scaling acoustic backscatter believed to arise from Caridina by a target strength (TS) for Antarctic krill, which superficially resembles Caridina. Here, we present our development of a new TS using the species' actual geometric shapes and a Distorted Wave Born Approximation (DWBA) model. At 120 and 70 kHz, we find TS ranges of -93.6 to -77.6 dB and -102 to -80.2 dB for typical Caridina length ranges. The frequency-specific TSs and between-frequency TS differences suitable for identifying Caridina echoes differ substantially from those for Antarctic krill. The new time-series of Caridina biomass after reanalysis of historic data will enable exploration of potential variation with fish biomass and environmental factors that may influence Caridina production. These new insights will enable progress towards production forecasting to underpin sustainable ecosystem-focused fisheries management, and regional food- and economic security.

S06-17197 Oral (ECOP)

How do the ecological traits of North Atlantic copepod communities shape their distribution?

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Analysing zooplankton dynamics is crucial to understand how ecosystems function and evolve under environmental and anthropogenic constraints. To encapsulate these complex dynamics, bioregionalisation approaches divide the ocean into units based on species distribution, thus defining regions structured by specific communities. Although plankton-based bioregionalisation has been extensively studied in the North Atlantic Ocean in recent years, it tends to treat zooplankton as passive drifters, overemphasising the role of hydro-physical processes in structuring spatial patterns. Zooplankton is dynamic, however, and exhibits specific ecological traits that influence ecosystem functioning. Here, we focused on copepod communities to assess the role played by their ecological traits in shaping large-scale spatio-temporal patterns. We first applied a network clustering framework on Continuous Plankton Recorder (CPR) data to delineate bioregions over the period 1966-2021 and then performed multivariate analyses on environmental processes and species traits. Our findings revealed that diel vertical migration behaviour plays a pivotal role in driving ecological partitions. We therefore analysed day and night samples separately, accounting for the CPR's limitation in sampling the water column, which led to redefined bioregions. While the northernmost bioregion remains consistent day and night, we detected significant variations in North Sea spatial patterns and in locations where highly migratory Metridia and Pleuromamma species dominate nocturnal communities. Untangling the intricate ecological processes that underpin biogeographic patterns, we demonstrate that holistic approaches – which integrate ecological traits – will provide invaluable insights into how pelagic communities will respond to global climate change in the coming decades.

S06-17198 Oral

Food web modifications shifted the functional structure of meso- and macro-zooplankton in the Southern North Sea

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The North Sea is changing rapidly, driven by modifications in human activities and impacts of climate change. Decreasing fishing intensity, reduction of nutrient loads from river discharges and rising water temperatures act in synergy, resulting in modifications to the structure of marine communities. Here we used a 43-year time series of meso- and macro-zooplankton community (> 500 µm, including decapod larvae and gelatinous zooplankton), monitored in the Southern North Sea, to describe their long-term changes in functional biodiversity. We used functional diversity indices combined with trait-based uni- and multivariate analysis to 1) investigate the temporal variability of functional biodiversity components, 2) describe the internal community changes constrained by external environmental drivers and 3) interpret the results in the context of community assembly mechanisms sustaining those changes. The results show that individual components of the functional biodiversity changed during different periods, but the early- 2000s appeared to be critical. Structural changes were tightly associated with modifications in the food web: traits like trophic regime and feeding strategy together with predation-risk traits, like body type or spines, were the most important internal drivers of changes, impacted, externally, by diatoms abundance and fish biomass. This resulted in environmental filtering processes responsible for the reorganisation of the community, leading to a significantly different functional community structure after 2005. These results not only support the occurrence of a true regime shift already reported for several trophic groups at taxonomic level but also highlight its translation to the functional level.

S06-17224 Oral

Eat, prey, love: can functional traits provide insight into bottom-up vs top-down forcing and long-term distribution patterns of copepods on the Agulhas Bank?

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The Agulhas Bank, the triangular continental shelf at the southern tip of Africa, is bordered by the warm Agulhas Current along its south-eastern margin and the cool Benguela upwelling system to the west. A quasi-permanent, mid-shelf upwelling feature known as the cold ridge is an important source of primary production, and the shelf ecosystem supports a number of fisheries, including small pelagic, demersal and squid. Zooplankton net samples collected annually in late austral spring were used to explore spatiotemporal variability in copepod biomass, distribution and taxonomic composition on the Agulhas Bank over a 24-year period, from 1988 to 2011. There was a significant long-term decline in total copepod biomass, attributable to declines in all stages of the dominant large calanoid Calanus agulhensis, as well as the smaller Paracalanidae and Clausocalanidae. However, no long-term trends were observed for other copepod taxa. Declines in the dominant calanoid taxa were negatively correlated with trends in pelagic fish biomass, but there were no clear complementary trends in situ temperature or chlorophyll a. These patterns are explored further using functional traits related to feeding mode, myelination (linked to escape response) and reproductive mode to integrate long-term spatial patterns in copepod distribution on the bank. Our ultimate objective is to explore relationships between copepod functional trait patterns and those of likely bottom-up (remotely sensed temperature, chlorophyll concentration, chlorophyll size) and top-down (biomass of small pelagic fish species anchovy, sardine and round herring) factors on the Agulhas Bank, and whether these have changed over time.

S06-17242 Oral

Zooplankton diversity and temporal dynamics in a coastal station in western Portugal (Northeastern Atlantic Ocean)

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Long-term monitoring of zooplankton assemblages provides essential knowledge to assess key factors impacting marine ecosystems. In the northeastern Atlantic area, CascaisWatch is one monitoring site operating since 2005, has allowed the collection of important data on the zooplankton communities of the area. The present work summarizes the knowledge collected until 2015 on the biodiversity and dynamics of zooplankton in the site. The results showed a year-round high productivity of the zooplankton abundance, biomass and diversity for the area, with no significant general trends or periodicity, despite the relatively lower winter and higher spring values. The results revealed two main transition periods with marked changes in species composition and dominance of the most abundant taxa. This shift was tentatively attributed to the extended annual dry season verified in Portugal after 2011, the low values of upwelling and precipitation, and the warmer waters. The zooplankton abundance presented an interannual increase for spring periods, and the proportion of Copepoda, the dominant taxa, was lower during summer months, corresponding to increased abundances of Mollusca, Diplostraca (Cladocera) and Cnidaria. In particular, the study shows an increasing abundance of the gelatinous species (particularly Cnidaria) for spring/summer months in recent years, suggesting changes in primary production and prey dynamics. Other relevant tendencies were the higher abundance of meroplankton, such as Bivalvia and fish larvae/eggs, and the decreasing trend in the abundance of the meroplanktonic coastal crustaceans, Decapoda and Cirripedia taxa, highlighting possible changes in the benthic coastal populations in the study region.

S06-17265 Oral (ECOP)

Copepod community shifts across shelf and oceanic gradients in the northeast Pacific from 1998-2022

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In the Northern California Current marine ecosystem, zooplankton data were collected monthly across the continental shelf and slope (1- 46 km) from the same transect (44.6°N) for the past 25 years. These high temporal frequency data have shown that copepod species composition exhibits strong seasonality, yet inter-annual low frequency variations in the community are largely driven by basin-scale oceanographic processes. Using this spatially expanded time series, we examined the cross-shore variations in the copepod community from 1- 370 km offshore of Newport, Oregon over 25 years. During the winter months, the community composition is similar offshore to 46 km from shore. However, during the spring and summer upwelling season, strong gradients develop in the species assemblages, with the nearshore community varying greatly compared to the community found 46 km from shore. During both winter and summer seasons, a strong transition occurs 120 km from shore, with higher copepod diversity and lower biomass found farther offshore. In years characterized by a strong marine heatwave (MHW), a unique copepod community spanned the shelf and offshore stations. We will present results on the mechanisms impacting zooplankton species composition and community structure across these strong oceanographic gradients, focusing on the contribution of local and basin scale drivers. Understanding how the copepod community changes beyond the shelf stations has direct implications for higher trophic levels such as sablefish, Pacific hake, and seabirds that utilize this offshore habitat. Results from this work could also be used as early-warning indictors of future climatic events such as El Niño and MHWs.

S06-17283 Oral (ECOP)

Size fractioned zooplankton as a systematic way to generate time series of whole community biochemical traits

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Marine food webs are strongly size structured – providing a framework to simplify communities for analyses that are expensive, arduous, or require significant biomass. Fatty acid and stable isotope analyses are powerful tools for resolving the structure of food webs but are challenging to apply to zooplankton communities composed of many different taxa and life stages, many of which are too small for efficient sorting and aggregation. Therefore, most trophic ecology research focuses on a few taxa and necessarily leaves out a portion of the community. We present four years of biweekly data on fatty acids and stable isotopes of an entire zooplankton community using size-structured sampling (250, 500, 1000, 2000, 4000 μm). Size classes were the greatest source of variability, indicating that they captured reproducible subsets of the community with shared characteristics. Within size classes there was also a strong seasonal pattern, likely reflecting shifting trophic sources and/or species composition. Although only a few years, this time series shows inter-annual variability in the biochemical characteristics of size fractions as well as their seasonal patterns. These differences capture shifts in the nutritional quality and quantity of zooplankton as prey for higher trophic levels across seasons and years. This dataset illustrates how a size-structured framework can be employed to implement ongoing, regular biochemical analyses of entire zooplankton communities.

S06-17285 Oral (ECOP)

Depth-related patterns of zooplankton within the epipelagic zone of Northern Gulf of Alaska

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The northern Gulf of Alaska zooplankton communities have been well characterized over the past quarter century, but there has been relatively limited reporting of the depth-related patterns in these communities. The larger-bodied and lipid-rich zooplankton in this region are sought after prey for many seabirds, marine mammals, and commercial fish; therefore, understanding their distribution in the water column is of particular significance. Here we explore the vertical and cross-shelf zonation of zooplankton in the upper 100 m of the water column using a towed Multinet with 505-μm nets that divided the water column into 20-m-thick strata during spring and early autumn from 1998-2022. We will focus our discussion on the four species of euphausiids (Euphausia and Thysanoessa) and several large-bodied copepods (Neocalanus, Calanus, Eucalanus, and Metridia) that are the primary crustacean components of this system. We will elucidate how their overall patterns are altered by interannual differences in climate forcing.

S06-17293 Oral

Temporal and spatial patterns in zooplankton assemblages as revealed by 25 years of observations along the Seward Line in the Northern Gulf of Alaska

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Over the past 25 years observations along the Seward Line have been providing observations on the status of the Gulf of Alaska's pelagic ecosystems.   Here we explore the three major spatial and temporal dimensions of variability present in this system: cross-shelf, seasonal and interannual. Both 150-µm and 505-µm samples were collected in the upper 100 m of the water column along the inshore-offshore Seward Line transect during spring and autumn from 1998-2023. Cross-shelf patterns in zooplankton assemblages are reflective of differences in ecotones along the Seward Line. Seasonal patterns are driven by the transition from the dominance of large-bodied diapausing copepods, such as Neocalanus spp., in the spring to a more diverse assemblage during autumn.   Major atmospheric indices, such as the Pacific Decadal Oscillation and El Niño Southern Oscillation, are correlated to much of the inter-annual variability in zooplankton communities both during spring and early fall. We will explore the different cross-shelf and basin-scale mechanisms shaping the planktonic communities in these two seasons.   This new understanding provides insights into what ecosystem changes can be expected as climate and these atmospheric indices continue to vary in the future.

S06-17325 Oral (ECOP)

The effect of El Niño Southern Oscillation on zooplankton biomass and copepod community composition in Australian waters

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The El Niño Southern Oscillation (ENSO) is the largest climate teleconnection in the world, regulating the movement of warm waters in the Pacific Ocean and, subsequently, global ocean processes and climate. Several long-term studies have shown ENSO impacts various terrestrial and marine ecosystems and organisms, but how it affects organisms at the base of the marine food web is less well known. Zooplankton are sensitive indicators of climate variability and environmental change, providing insights into ecosystem health and food for higher trophic levels. Given the influence ENSO has on Australian coastal waters and ecosystems, we used the largest zooplankton dataset in Australia, from the Integrated Marine Observing System (IMOS) National Reference Station network, to investigate the variation of zooplankton biomass and copepod community composition with ENSO. The study covers seven sites around Australia, representing different climates and oceanographic contexts. Our results found that the zooplankton biomass decreased during La Niña phases at six of the seven sites, except at North Stradbroke Island. Copepod communities showed an overall increase in diversity during La Niña and lower diversity during El Niño. Our analyses found that Paracalanus denudatus were indicative of La Niña events. Several species, including Nannocalanus minor and Lucicutia flavicornis, had significant indicator values for El Niño events. With future climate change models predicting more extreme El Niño and La Niña events, zooplankton biomass and copepod communities could see increased interannual variability, with impacts that will be felt at higher trophic levels and in fisheries.

S06-17328 Oral

The diversity and power of zooplankton indicators for assessing ecosystem state and trends

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Plankton form the base of the marine food web and are sensitive indicators of ecosystem health and global change. Observations, experiments, and models show that plankton play a pivotal role in ecosystem dynamics, fishery productivity and system resilience. Here we describe several sensitive indicators of ecosystem change based on the biodiversity, biomass, and size spectra of zooplankton. We use zooplankton data from Australia's Integrated Marine Observing System (IMOS) that includes two long-term monitoring plankton surveys: the seven National Reference Stations, and the Australian Continuous Plankton Recorder (AusCPR) survey, integrated with biogeochemical and physical parameters from other IMOS data sources. We describe three case studies: (i) calculating an index of the strength of a large western boundary current based on thermal preferences of the copepod community; (ii) deriving a multivariate index of the potential impact of ocean acidification using calcifying zooplankton; and iii) assessing the multi-decadal impact of climate change by calculating the community temperature index of copepods. These case studies highlight the power of zooplankton indicators and the importance of long-term datasets such as IMOS.

S06-17347 Oral

Temporal patterns of zooplankton biomass and functional group responses to environmental drivers off the west coast of Vancouver Island, British Columbia, Canada.

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Situated at the northern end of the California Current system, the west coast of Vancouver Island (WCVI) is a productive transitional zone that lies between the poleward flowing Alaska Current and the equatorward California Current. Zooplankton composition and biomass along the WCVI are subject to variation in the position of the transitional streamline and strong seasonality in timing and intensity of upwelling and downwelling. Two long-term WCVI zooplankton time series: southern Vancouver Island (SVI: 1979-present) and northern Vancouver Island (NVI: 1990-present) are sufficiently long to reference against seasonal and annual climatological means. The use of groupings defined by biogeographic affinity increases sensitivity to variation of climate indices, such as the North Pacific Gyre Oscillation. During the 2014-2016 marine heatwave, the biomass of both endemic boreal shelf and subarctic oceanic copepods were ~2-3X lower than climatological means. In contrast, biomass anomalies of ‘southern’ affinity copepods were 3-10X greater on the shelf and offshore. Starting late 2020, this pattern flipped with the onset of La Nina conditions. Venello et al. (2021) assembled functional traits for 55 WCVI species, identified eight functional groups, and calculated annual biomass anomalies during 1980-2016. During this period, functional group biomass anomalies were less variable than biogeographic anomalies (thereby demonstrating some functional redundancy) and were best correlated with different climate indices. Functional traits are a useful tool for bridging the gap between taxonomic- and process-based measurements. Here we update, compare, and extend the time series of indicator and functional group biomass anomalies to 2022 to both SVI and NVI.

S06-17357 Oral (ECOP)

Finding synchronicity between copepod and phytoplankton community shifts in the Northern California Current from 2001-2018

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Copepods have long been used as ocean ecosystem indicators for their importance in the marine food web and their strong relationships with both climatological and local physical indices. Despite these strong correlations, seasonal and interannual shifts in the copepod community often lag, but sometimes lead, shifts in ocean conditions. Phytoplankton, an important food source for copepods, respond to abiotic factors (temperature, nutrients, light availability) on much faster time scales. Therefore, understanding how the species composition and abundance of phytoplankton change in response to changing ocean conditions may provide insight into what drives the seasonal and interannual shifts in the copepod community. We investigated whether seasonal and interannual shifts followed those found in the copepod assemblage, whether there were temporal lags, and whether certain phytoplankton taxa could be used as early warning indicator species of impending shifts. We also investigated what environmental drivers best explained the patterns. Phytoplankton and copepod data are from twice monthly to monthly sampling (n = 326 sampling dates) on the continental shelf (60m of water) off the central Oregon coast, USA for seventeen years (2001 - 2018). This high frequency, long time series, provides a robust dataset to track changes in the ocean ecosystem including phenological shifts, responses to, and recovery from, extreme events like marine heatwaves, and long-term changes in response to climate variability and change.

S06-17358 Oral (ECOP)

The role of transport and environmental variability influencing the spatiotemporal patterns of zooplankton in the Northern California Current, USA

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Zooplankton play a key role at the base of the food chain, because their distribution, community composition, and abundance set the table in terms of food quantity and quality for higher trophic levels. Therefore, understanding the biophysical processes that affect the interannual and spatial variability of zooplankton is a long-sought topic of marine and fisheries ecology. Using two decades of biological observations with co-located information on the pelagic habitat, we aim to understand the physical and biological variables driving the spatiotemporal patterns of zooplankton with differing life history patterns. Zooplankton and hydrographic data were collected each June from 1998 – 2022 at stations located on the inner continental shelf (30m) offshore to the shelf break (200m) along six transects (44.6˚N – 48˚N) in the Northern California Current. Observational data are complimented with Lagrangian particle tracking using Regional Ocean Modelling Systems (ROMS) to investigate whether spatiotemporal patterns in zooplankton match those in ocean currents. Because it is expected that different biophysical processes will favor one life history strategy over the other, two example taxa groups were used - pteropods (holoplankton) and crab larvae (meroplankton). Because holoplankton complete their life cycle at sea, we expect that conditions favorable for reproduction and survival are likely strong drivers of the spatiotemporal patterns. Unlike holoplankton, the population persistence of meroplankton is inextricably linked to larval survival, and the return of larvae to habitats favorable for survival. Therefore, circulation features and vertical migration behaviors that favor nearshore retention are likely strong drivers of their spatiotemporal patterns.

S06-17359 Oral

Zooplankton variability in the waters around Iceland

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The waters south and north off Iceland are very different both oceanographically and biologically with the rather stable and warm North Atlantic waters south and west of Iceland and the more variable and colder Arctic and sub-Arctic waters, north and east of Iceland. Long-term changes in zooplankton biomass around Iceland, in relation with hydrography and environmental variables, in May-June are examined at 14 transects, total of 86 stations, the years 1961-2021. Since 1990 zooplankton community structure has been analyzed at 2 transects, one south and one north of Iceland. No unidirectional trend in biomass has been observed. Higher biomass is observed in shelf waters off the south and west coasts and in the oceanic waters north, northeast and east of Iceland where Arctic influences is greater. Irregular fluctuations in biomass are observed in the south with rather high biomass and high annual variance. Zooplankton biomass north of Iceland is higher in warm years than in cold years. Earlier studies on zooplankton community structures south and north of Iceland using multivariate analysis (PCA and RDA) have shown that in neither region was a unidirectional temporal trend in species composition. A significant year-to-year variability in community structure was observed both in the south and north, with salinity and used nitrate dictating the variability to the south and temperature to the north (Monte Carlo permutation tests, $P<0.05$). In this presentation we present an update of this community study.

S06-17374 Oral (ECOP)

Synergistic impacts of environmental drivers on mesozooplankton community composition in the Ulleung Basin: A decadal analysis

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The mesozooplankton community may be used as an indicator of climate change due to their rapid response to changing environment. The sea surface temperature exhibited an increasing trend over the last decade during the summertime in the Ulleung basin, East/Japan Sea. The structural changes of mesozooplankton community in relation to the climate-driven factors in the surface mixed layers of Ulleung basin were investigated during the summers of 2009-2022. The anomalies of foraminiferans, Pyrocystis noctiluca, and larvae of macrobenthos showed a significantly increasing long-term trend ($p < 0.1$) whereas Noctiluca scintillans, chaetognaths, and ostracods showed a slightly increasing long-term trend. The mesozooplankton showed a slightly increasing long-term trend with peaks in 2015 and 2020. The two peaks of mesozooplankton abundance were mainly due to the dominance of N. scintillans, and the common feature was the close passage and meandering of East Korea Warm Current (EKWC). The next dominant taxa were thaliaceans and P. noctiluca in 2015 and 2020, respectively. The volume of Tsushima warm current in the western channel (v-west) was 1.3 times greater in 2020 compared to 2015, and the occurrence of marine heatwave was detected in 2020 while not detected in 2015. The peaks of mesozooplankton were due to the meanders of EKWC, however, the strong v-west together with the occurrence of MHW may have transported a high abundance of subtropical species P. noctiluca and allowed its persistence during 2020. Thus, the climate-driven factors may have a synergistic influence on the long-term changes in mesozooplankton community composition.

S06-17393 Oral

Mesozooplankton communities in the Aegean Sea (Eastern Mediterranean): An analysis in space and time

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Time-series are crucial to understand the status of zooplankton communities and to anticipate changes that might affect the entire food web. Long-term time series allow us to understand impacts of multiple environmental and anthropogenic stressors, such as chemical pollution and ocean warming, on the marine ecosystems. The objective of this study was to provide an in- depth analysis of the dynamics of mesozooplankton community composition, encompassing both temporal and spatial scales, in the Aegean Sea (Eastern Mediterranean). The data used came from multiple oceanographic cruises during the last 30 years (1991-2021) in the Aegean Sea. Zooplankton have been collected using a 200 μm WP2 net by vertical tows from 100 m to the surface. Among zooplankton groups, Copepoda and Cladocera were identified to species level (when possible) and Copepoda were classified according to sex and stage (females, males and juveniles, when possible). Our results indicate that a-diversity patterns characterizing the Aegean Sea remained approximately the same. Moreover, a differentiation between seasons and locations was observed, with spatial differences being more prominent. The multivariate regression tree model was successful in capturing and explaining a significant portion of the variation in the mesozooplankton data. Temperature was identified as a key driver influencing the distribution and composition of mesozooplankton in the studied ecosystem. Overall, these findings provide insights into the ecological relationships and associations among the analysed taxa in the Aegean Sea, shedding light on their co-occurrence patterns, potential interactions, and ecological preferences.

S06-17401 Oral (ECOP)

Long-term warming and human-induced plankton shifts at a coastal Eastern Mediterranean site

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Plankton communities are sensitive to environmental changes and serve as valuable indicators for assessing human-induced pressures like climate change and waste-water discharge. When such phenomena co-occur, the disentanglement of their effects on plankton remains challenging. Here, 26 years (1988-2015) of biweekly in-situ chlorophyll-a concentration, mesozooplankton biomass and remotely-sensed sea surface temperature (SST) data are utilized to investigate long-term changes of plankton biomass and timing of growth (phenology) in relation to oceanic warming and anthropogenic nutrient loading from waste-water discharges, in a coastal region of the Saronikos Gulf (Eastern Mediterranean Sea). The Psittalia Waste-Water Treatment Plant (WWTP) was installed in 1995 to address untreated sewage discharge in the region. After 2004, a significant decrease in nutrient concentrations has been reported, due to the implementation of the secondary treatment stage of WWTP. During a period of higher nutrient input (1989-2004), a temporal mismatch between zooplankton and phytoplankton, and a positive association between zooplankton growth and SST, are evident. In contrast, during the warmer and less mesotrophic period 2005-2015, an earlier seasonal timing of the main zooplankton growth (related to copepod abundance) and the emergence of a secondary autumn growth period are synchronized with phytoplankton growth. After the improvement of water quality, an abrupt negative interannual relationship between SST and zooplankton, and a reduction in summer zooplankton biomass, are detected, mostly linked with cladoceran abundance. Alterations in plankton phenology and biomass, driven by human-induced pressures, necessitate further investigation into species-specific changes, trophic match-mismatches, and the potential impacts on higher trophic levels.

S06-17402 Oral

NERACOOS time series indicates zooplankton responses to changing oceanographic conditions in the western Gulf of Maine

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The Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS) oversees a regional collaboration to observe planktonic diversity at two fixed stations in the western Gulf of Maine (GoM): the Wilkinson Basin Time Series (WBTS) station (initiated in 2005) and the Coastal Maine Time Series (CMTS) station (initiated in 2008). The WBTS and CMTS stations are strategically located to monitor planktonic ecosystem characteristics in the Maine Coastal Current, a regional production driver, and in Wilkinson Basin, the primary overwintering habitat for the energy-rich foundation species, the copepod Calanus finmarchicus. The Calanus Index, a seasonal index of C. finmarchicus abundance at the time series stations, has shown a recent 70% decline in summer, fall, and winter, but not in spring. The abundance decline coincides with a 2010 shift from cooler to warmer water masses advected into the GoM, and to an observed increase in chlorophyll a standing stock in late winter/early spring which favors early C. finmarchicus egg production. Analysis of zooplankton community composition before and after 2010 also indicates a shift to smaller copepods dominated by Centropages typicus, Pseudocalanus spp. and Oithona spp. and Metridia lucens. The Calanus Index is a component of the NERACOOS Integrated Sentinel Monitoring Network (ISMN) and the Gulf of Maine Marine Biodiversity Observation Network (MBON), and serves as a sentinel indicator of subarctic GoM pelagic ecosystem function. Present stakeholder applications for its use include modeling North Atlantic right whale foraging habitat and modeling recruitment of sand lance populations preyed upon by humpback whales in the region's Stellwagen Bank National Marine Sanctuary.

S06-17419 Oral

Unlocking the past to predict the future: Enhancing species distribution modelling with long-term data

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While accurately predicting species distributions is essential for conservation and management actions, the critical step of model evaluation remains unresolved. Various methods have been introduced to evaluate model outputs, but they all have been criticized. Hindcasting, which involves projecting into past time periods, offers a promising way to enhance species distribution model validation. To capture the complex species-environment interactions at different spatial and temporal scales, and to reconstruct the dynamics of a species in a robust manner, relying on long-term time series is essential. Unfortunately, knowledge of historical species distributions is often lacking, and only a few datasets allow for hindcasting. The Continuous Plankton Recorder Survey, the world's most extensive marine monitoring program, is one such dataset. Here, we explore and quantify how the use of long-term datasets enhances the evaluation of species distribution modelling by relying on an intensive collection of plankton samples from the ocean's surface waters for over six decades. Through a case study, we show how this approach benefits our understanding of how environmental conditions influence species distributions and how this knowledge can refine models accordingly. By testing a range of correlative models against historical data, we demonstrate how hindcasting can identify potential modelling biases and assess which class of models yields more realistic predictions of range dynamics, a prerequisite for forecasting the effects of climate change. Our results emphasize the critical role that long-term datasets play in advancing our understanding of ecological dynamics and developing evidence-based approaches to mitigating environmental challenges.

S06-17426 Oral (ECOP)

Changes in copepod size in response to warm and cold conditions during spring in the Eastern Bering Sea

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Large marine ecosystems of Alaska are experiencing significant warming, and one response to warming predicted by ecological theory is a decline in organism body size. Here we report preliminary results for NPRB Project 2008: The effect of global warming on long-term changes in copepod size in the Bering Sea. We used an archive of preserved specimens to measure body size (prosome length) of copepods across warm and cold periods in the eastern Bering Sea. Average prosome length for large copepods (Calanus and Neocalanus) was lower during the warm years, whereas prosome length for smaller copepods (Acartia, Oithona, Pseudocalanus, and Metridia) did not show differences. The differences in body size translate to differences in individual mass and lipid content. For example, the average size of Calanus C5 during cold years was 0.27 mm larger than during warm years. Based on length-weight regression, this translates to C5 Calanus being ~20% heavier and having 10% more lipid content during cold years. This suggests that the fewer Calanus observed during warm conditions are smaller and less lipid rich compared to cold years. This has implications for the eastern Bering Sea food web as many species rely on Calanus as an important forage item, including Walleye pollock, seabirds, and the critically endangered North Pacific right whale. We hypothesize that warming in Alaska ecosystems has caused copepod body size to decline over time. Should such a decline be detected, it would suggest a shifting relationship with higher trophic levels with ecosystem wide consequences.

S06-17028 Poster (ECOP)

Impact of ENSO on zooplankton community structure and anchovy Engraulis japonicas resources in the southern Yellow Sea

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The disastrous impact of ENSO on the global fishery ecological environment has regional specificity. The reversals of different environmental conditions caused by ENSO phase transitions (El Niño and La Niña) have led to significant changes in the structure of marine biological communities and ecosystem services. In the southern Yellow Sea, zooplankton abundance was higher during ENSO cold phase (La Niña) than that during ENSO warm phase (El Niño), with the increase of water temperature. Higher copepods and gelatinous zooplankton abundances during La Niña may be attributed to high temperature and strong current transport. However, in contrast to the increase of zooplankton abundance, the anchovy Engraulis japonicas resources decreased. The internal mechanism leading to the difference needs to be further explored, by using long time series data and considering the nutritional dynamics.

S06-17080 Poster

The SCAR Southern Ocean Continuous Plankton Recorder (SO-CPR) Survey: the first three decades

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The Continuous Plankton Recorder (CPR) can collect surface zooplankton continuously for 450 nautical miles during a single tow at normal ship speed. It is an effective and efficient monitoring tool for detecting surface zooplankton abundances, species composition, and distribution patterns over large oceanic scales. The SCAR (Scientific Committee of Antarctic Research) Southern Ocean CPR (SO-CPR) Survey provides the largest comprehensive and systematic Antarctic zooplankton data set, spatially and temporally, using a consistent sampling methodology ideal for the purpose of mapping the seasonal, inter-annual, long-term and spatial variation in plankton diversity, as well as to use plankton as sensitive indicators of environmental changes to monitor the health of the Southern Ocean. Approximately 290,000 nautical miles have been sampled since the commencement of the SO-CPR Survey by Australia in 1991, representing some 57,000 samples for 290+ zooplankton taxa coupled with environmental data. Much of this work has already been published in over 70 CPR based research papers, chapters, atlases, and reviews.

S06-17203 Poster

Seasonal succession, vertical distribution and life cycle of the mesopelagic copepods genus Pleuromamma in Sagami Bay, Japan.

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Sagami Bay is characterized by a sudden deepening of the water a short distance from the shore. In this study, community structure, vertical distribution and life cycle of Pleuromamma copepods were analyzed using samples collected for one year in four layers between 0−500m depth at a station 3km from shore. Three species of Pleuromamma appeared in this area, of which P. gracilis was the most dominant. This copepod was scarce in winter but gradually increased from spring to summer, reaching a maximum (2175 inds/m^2) in September. P. abdominalis was the second most abundant species, and although it was also scarce in winter, it increased to 479 and 906 inds/m^2 in August and December, respectively. Compared to the above two copepods, P. xiphias was less abundant, with a maximum of 108 inds/m^2 (December 2009). Most of the populations of P. gracilis and P. abdominalis occurred in the 100−300m layer, with 45−100% and 56−98% of the total individuals, respectively. In the 30−100m layer contained 9−50% and 4−37% of total individuals of P. gracilis and P. abdominalis, respectively. P. abdominalis was relatively common in the 300−500m layer (up to 38% of total individuals). P. xiphias was distributed in the 300−500m layer for more than 80% of the total collection during most sampling periods. Almost all copepodite stages of P. gracilis and P. abdominalis appeared throughout the year. Time-series tracing of the peak of each copepodite stages, suggested that P. gracilis and P. abdominalis has four and three generations per year, respectively.

S06-17209 Poster

Spatio-temporal variability of the zooplankton communities in the W Mediterranean Sea (2010-2023)

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Variability in the spatial and seasonal distribution of the mesozooplankton abundance in the W Mediterranean Sea was assessed from 2010 to 2023. There were significant differences in mesozooplankton abundance between the SW (Alboran Sea) and NW (Balearic Sea) basins. Copepods dominated the mesozooplankton during winter and spring, whereas cladocerans were the most abundant group in summer, although occasionally surpassed by doliolids, mainly in the NW coast. Abundance of appendicularians peaked in winter-spring in both basins; whereas euphausiids and copepod nauplii maxima occurred during spring and summer, in the Balearic and Alboran Seas, respectively. However, chaetognatha abundance was spatially and seasonally constant over the studied period. Our results suggest that increasing temperature and extended summer periods are the main drivers of mesozooplankton variability.

S06-17377 Poster (ECOP)

Seasonal and interannual variation of the calanoid copepod, Metridia pacifica, in the northern Japan Sea and regional comparisons: influence of unique deep-sea fauna in the Japan Sea

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Metridia pacifica is a predominant copepod in the subarctic Pacific. Despite the dominance, long-term and interannual variations remain unclear, due to their active diel vertical migration (DVM). This DVM causes significant day-to-night variations in traditional 0-150 m sampling. For better evaluation of DVM mesozooplankton, we have conducted 0-500 m sampling around Hokkaido since 2008. In this study, we investigated the seasonal and interannual variations of M. pacifica from 2008 to 2022 in the northern Japan Sea and compared regional differences in maximum annual abundance. The abundance and biomass peaked from spring to summer and showed high levels in the early 2010s, which declined by the late 2010s. The interannual variations correlated with surface temperature anomalies in winter and summer, which might vary the duration of the spring bloom. However, regional comparisons revealed the northern Japan Sea had the highest annual abundance among the subarctic Pacific and marginal seas, not correlating with regional variations in spring blooms. This higher abundance peak in the Japan Sea was mainly composed of young stages (CIII-CV) in spring, with a lower abundance of adults throughout the year. This pattern indicates a low mortality during their growth season. This low mortality may be caused by minimal competition and predation in the mesopelagic zone of the Japan Sea, characterized by low deep-sea fauna due to the shallow straits preventing the inflow. Our findings suggest that interactions with other organisms, such as competition or predation, might play a larger role in driving variations in dominant copepods.

Session 7: The role of microzooplankton in biogeochemical cycling and food webs

Convenors:
Ruth Eriksen (Australia), corresponding
Hongbin Liu (China)
Jun Sun (China)
Wuchang Zhang (China)

Invited Speakers:
Michael Landry (Scripps Institution of Oceanography, UC San Diego, USA)
Hongbin Liu (Hong Kong University of Science and Technology, Hong Kong)
Luciana Santoferrara (Department of Biology, Hofstra University, Hempstead, NY, USA)

Marine microzooplankton (<200 µm) are important grazers in the microbial food web, as well as a source of food for the mesozooplankton. There is a high level of morphological and functional diversity in the microzooplankton including ciliates, flagellates, radiolarian, foraminifera, and small metazoans, with a range of strategies for energy production. Microzooplankton play a critical role in biogeochemical cycling in marine systems, and environmental stressors such as ocean warming and acidification may have enormous influence on these fast-growing protists.

- Taxonomy, systematics and biogeography of microzooplanton
- Biodiversity of microzooplankton and their role in estuarine, coastal and oceanic systems
- Advances in understanding microzooplankton influence on biogeochemical cycling
- Microzooplankton in a changing ocean of warming, acidification and deoxygenation
- New methods for studying the ecological role of the microzooplankton

S07-17237 Invited (ECOP)

Microzooplankton ecological roles in an urban estuary affected by summer hypoxia

Abigail Salgado, Aleena Qureshi, Jodi Dharam, Khabiba Shahid, Carissa Kissoon, Amedea Cipriano and Luciana **Santoferrara**

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Eutrophication and hypoxia dramatically alter trophic dynamic and nutrient cycling in impacted coastal waters, but little is known about the microbial communities that drive and interact with these changes. In this context, microzooplankton species play important roles as consumers and recyclers of the organic matter that fuels hypoxia. We have launched a multi-annual program to quantify the abundance, diversity and trophic interactions of microzooplankton and other microorganisms in a seasonally hypoxic embayment of Long Island Sound, USA. To compare normoxic and hypoxic conditions, we measure environmental variables (dissolved oxygen, chlorophyll and N nutrient concentrations, etc.) and collect fixed (Lugol's, mixed aldehydes) and non-fixed surface and bottom waters at four stations every ca. two weeks during summer. For 2022 and 2023, we have analyzed: 1) abundance and biomass of microzooplankton (mostly ciliates, dinoflagellates, copepod nauplii) by microscopy; 2) prokaryote abundance by flow cytometry; and 3) DNA metabarcodes of microeukaryotes and prokaryotes (V4 region of the small-subunit rRNA genes). Our preliminary results show relatively stable microzooplankton and prokaryotic abundances across stations, depths or dates, and a weak correlation with dissolved oxygen. Instead, we detected significant changes in the diversity and community composition of microeukaryotes and prokaryotes in correlation with the progression of summer. Fluctuations in the relative abundance of certain microeukaryotic, bacterial and archaeal taxa suggest a coupling of food web and biogeochemical processes that influence water de- and re-oxygenation. Future work includes metagenomics and prey consumption experiments to test hypotheses on functional diversity and trophic interactions.

S07-17386 Invited

Will warming cause mixoplankton to become more heterotrophic?

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The shift between photoautotrophic and phagotrophic strategies in mixotrophic protists significantly impacts the planktonic food webs and biogeochemical cycling. Considering the projected global warming, it's crucial to study how temperature affects this transition. We found that constitutive mixotrophic dinoflagellate Lepidodinium sp. can adjust its phagocytosis intake according to inorganic nutrient concentrations. Its thermal sensitivity (measured as activation energy Ea, eV) was significantly higher in mixed trophic mode (0.69−0.89 eV with sufficient food) than in autotrophic mode (0.30−0.37 eV without food). This finding is consistent with the results of the predominantly heterotrophic mixoplankton and provides experimental evidence for the hypothesis that mixotrophic protists may become more heterotrophic with increasing temperature. Our transcriptomic analysis showed that phagocytosis-related pathways, including focal adhesion, regulation of actin cytoskeleton, and oxidative phosphorylation, were significantly stimulated in Lepidodinium sp. when cryptophyte prey were added. We further compared the expression of their photosynthesis and phagocytosis genes in the global ocean using the global metatranscriptome dataset. It was found that Lepidodinium sp. became more phagotrophic with rising temperatures when the ambient chlorophyll a concentration was higher than 0.3 $mg.m^{-3}$ (20.58% of the ocean surface) but became more photoautotrophic with rising temperatures when the chlorophyll a concentration was between 0.2–0.3 $mg.m^{-3}$ (11.47% of the ocean surface). Overall, we highlight the key role of phagocytosis in phago-mixotrophy and propose that the expression profile of phagocytosis genes can be used as a molecular marker to indicate the phago-mixotrophic activity in situ.

S07-17718 Invited

The microzooplankton trophic link: Can conventional understanding of food web structure explain mesozooplankton biomass variability in the oceans?

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Over the decades since the microbial loop hypothesis transformed understanding of marine food web relationships, microzooplankton have emerged as the dominant grazers of primary production globally and the major transfer link to higher trophic levels. The current conventional paradigm of food web structure inserts one full trophic level of microzooplankton heterotrophic consumption, consequently a substantial energy drop, between phytoplankton and mesozooplankton. Alternatively, trophic flows might be up to three times more efficient for a paradigm based on widespread mixotrophy. Can conventional understanding explain mesozooplankton biomass variability in the oceans? Using a dataset of contemporaneous full-euphotic-zone measurements of primary production, phytoplankton C:Chla, size-fractioned mesozooplankton biomass and grazing rates of micro- and mesozooplankton from tropical to temperate ecosystems of the major oceans, I examine whether and how the flows originating from primary production can satisfy mesozooplankton carbon demand and what the results imply about the trophic structure and roles of microzooplankton in epipelagic food webs. The presentation will highlight the importance of integrated multi-trophic level studies for addressing complex system-level questions and constraining mechanistic interpretations of ecological relationships.

S07-17054 Oral

Tintinnid biogeography in oceanic waters around the world

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Tintinnids are planktonic ciliates with shells (lorica) of species-specific shapes, size and decorations (collars, windows, etc.). As the largest component of the microbial food web, they are links between microbial food web and traditional food chain. Most of the members of microbial food web have poor taxonomy due to their small size and lack of prominent taxonomical characteristics. However, tintinnid had good species occurrence record in world oceans thanks for their shells which were used as taxonomic criteria in most cases. Previous tintinnid biogeography was based on genus level. Here we present our study on the tintinnid biogeography in the species level in oceanic habitats covering Arctic, subarctic, subtropical gyres and Southern Ocean. The characteristic species were determined in these gyres. The intrusion of subarctic tintinnid species into arctic gyre is examined. The transition zone of subarctic and subtropical species showed asymmetry distribution in its two sides. The species Dadayiella ganymedes could be used as the indicator of the edge of subtropical central gyre in both Atlantic and Pacific Oceans, and may be in Indian Ocean, too. While there is no vertical distribution pattern of species in the Subarctic Gyre, species in the Arctic Gyre and subtropical gyre showed distinct vertical preference. Since tintinnid is member of the protists with single cell and bipartition, the pattern might be extended to some or all the members of the microbial food web.

S07-17229 Oral

Integrating microscopy and multigene metabarcoding to unravel the hidden microzooplankton diversity

Lidia **Yebra**[1], Miriam Domínguez[1], Ana María Cabello[1], Soluna Salles[1], Jessica Vannini[2], Genuario Belmonte[2], Rowena Stern[3], Nerea Valcárcel-Pérez[1], Isabel Ferrera[1], Jesús M. Mercado[1]

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Microplankton is an heterogeneous group of organisms ranging between 20 and 200 µm in size. Morphological characterization of its diversity is challenging as it includes Chromista, Protozoa, and Metazoa (adults and larvae). We characterized the composition of the microzooplankton community (heterotrophic and mixotrophic) collected with a CalVET net (50 µm mesh), in a coastal area affected by urban wastewater discharges in the N Alboran Sea (SW Mediterranean). We applied an integrative taxonomic approach, combining metabarcoding of the mtDNA cytochrome oxidase I (COI) and the V4 region of the 18S rRNA (18S) genes with morphological microscopic identification of organisms. Both methods showed differentiated coastal and offshore microzooplankton assemblages. The dominant taxa varied depending on the method used, with Dinophyta accounting for 64-85% of the microscopy counts but Arthropoda representing up to 98% or the COI and 18S reads. Computing protists and metazoans relative abundances separately, both microscopy and metabarcoding revealed unicellular communities dominated by thecate Dinophyta, followed by Ciliophora. Metazoa microscopy counts were dominated by eggs, followed by Copepoda nauplii in offshore waters, whereas by Appendicularia and Mollusca larvae in the coastal stations. COI reads also corresponded mostly to Copepoda and Mollusca in shallow waters. However, 18S reads were dominated by Copepoda and Thecostraca. Despite the identification level differed among methods and taxa, the integrated approach allowed disentangling the hidden diversity of this community.

S07-17372 Oral

Tintinnids as passive samplers: what do agglutinating species reveal about their surroundings?

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Tintinnid ciliates are a stunningly diverse part of the microzooplankton, with an estimated 1200 species found worldwide. Species distributions can be cosmopolitan, or restricted to more defined habitats such as estuaries, or polar /sea-ice regions. There are two broad morphological groups that include taxa with 1) hyaline (naked) lorica, and 2) agglutinating taxa that selectively collect and integrate living (biogenic) or non-biogenic particles into the lorica construction. Biogenic particles may include whole phytoplankton, brokenfragments, or specific parts of phytoplankton cells, while non-biogenic particles are exclusively mineral grains. Some polar tintinnid taxa have been observed to attach living diatoms to the lorica, confirmed by fluorescence microscopy, while other taxa choose fragments of diatoms, or individual coccoliths from a small group of coccolithophorids. The exact mechanism of particle preferences, selection, and attachment of living or dead material is not well understood.
In our surveys on the Southern and Indian Oceans, we have observed many of these stunning partnerships. In this presentation we examine correlations between the diversity and abundance of phytoplankton attached to the outside of the lorica and the diversity and abundance of the same species in the water column. We explore the possibility of using tintinnids as living "passive samplers" in certain parts of the world's oceans.

S07-17447 Oral

Microzooplankton community in Eastern Indian Ocean

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The Eastern Indian Ocean is a low primary production region, and its often unpredictable climate and monsoon patterns have a substantial effect on the distribution of plankton. As the main grazers of primary producers, microzooplankton are the central link in the organic carbon transfer of microbial food webs playing an ecological function that may be even more important in low production environments. Unfortunately, there is a lack of comprehensive surveys on the basics of microzooplankton communities in the Eastern Indian Ocean. Here we investigated long-time-scale changes in microzooplankton community in the open ocean of the Eastern Indian Ocean under different hydrographic conditions. Our research revealed a high species diversity and a wide coverage of taxa, including ciliates, mixtrophic or heterotrophic dinoflagellates, foraminifera, radiolarians, and copepod nauplii. Currently, we have identified 340 species of microzooplankton of which ciliates and mixtrophic or heterotrophic dinoflagellates are the main species groups. 20 species of modern planktonic foraminifera, 60 species of radiolarians, and 5 species of peritrich ciliate were reported for the first time in this area, with detailed descriptions of their morphology and geographical records. The dominant group is dominated by eurytopic species, and the distribution pattern of the dominant ciliate species is more sensitive to changes in monsoon currents. There may be indicator species for the periodic currents of the Eastern Indian Ocean in this taxon. Microzooplankton community tend to have higher abundance and feeding rates in nearshore freshwater flushes and upwelling waters. However, there was no significant correlation between the abundance, carbon biomass, and morphological diversity of microzooplankton and chlorophyll a concentration. Additionally, temperature was found to be the main factor influencing zooplankton distribution in the Eastern Indian Ocean. Finally, picophytoplankton or nanophytoplankton and microzooplankton made up a larger proportion of the abundance, which may explain the adaptation to low levels of primary production.

S07-17698 Oral (ECOP)

A new Protocruzia species (Ciliophora: Protocruziida) isolated from the Mariana Trench area

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A new species of Protocruzia, isolated from the deep-sea Pacific Ocean (>3000 m depth) in the vicinity of the Mariana Trench, is described based on morphological and molecular data. The systematic status of the ciliate genus Protocruzia has long been highly ambiguous, and Protocruzia species have been assigned to an independent class until recently. In the present study, we described Protocruzia marianaensis sp. n. as a small (25–32×14–17 μm in vivo) drop-shaped ciliate, with longitudinal furrows along the ciliary rows on the right side, six adoral membranelles, eight somatic kineties (six on the right lateral side and two on the left), and one macronucleus comprising of 7–11 nuclear globules. Phylogenetic analyses inferred from small subunit rRNA gene sequences revealed that seven Protocruzia species in the phylogenetic tree formed a fully supported clade representing an independent class. Protocruzia marianaensis sp. n. was established to be most closely related to P. adhaerens, with a sequence similarity of 96.64%, and was found to be able to survive at both atmospheric pressure and hydrostatic pressure of 320 bar, thereby indicating effective barotolerance.

S07-17053 Poster (ECOP)

Importance of the microbial loop on the zooplankton trophodynamics across the Southeast Pacific

Igor Fernández-Urruzola[1], Antonio Bode[2], Natalie Loick-Wilde[3], Wolfgang Schneider[1,4], Dhugal Lindsay[5], Susana Cabrera-Nuñez[4], Ruben Escribano[1,4]
Presented by Susana **Cabrera-Nuñez** on behalf of Igor Fernández-Urruzola

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The number of trophic steps within a planktonic food-web regulates the transfer efficiency toward higher trophic positions, being a key determinant for the ecosystem functioning and services. Although it has been generally assumed shorter food-webs in productive marine ecosystems, the planktonic food-web structure and any potential changes in its complexity along the productivity gradient in the Southeast Pacific is currently unresolved. For the first time in this region, an innovative approach such as the compound specific nitrogen stable isotope analysis of amino acids has been used to better understand the trophodynamics of the mesozooplankton community across three distinct oceanographic ecoregions with contrasting environmental conditions. Collectively, our results challenge the classical paradigm of higher herbivory with increasing the ecosystem productivity, and rather demonstrate that the small microzooplankton and protozoa play an important role in the energy transfer along the coastal-transition zone of the Humboldt Current System. This study thus provides mechanistic understanding of the functioning of the planktonic food-web in the region and will contribute to the development of more accurate biogeochemical models. Furthermore, our findings open new research questions about the lengthening of the planktonic food-web along these ageing upwelled waters and its control on the fish stocks.

S07-17082 Poster

Seasonal variations in the microzooplankton community of the Benguela Current

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Microzooplankton play a crucial role in both low and high productive marine food webs. The Benguela Upwelling System (BUS) at the western coast of southern Africa is one of the most productive upwelling systems of the world. It is divided into a northern and a southern subsystem (nBUS and sBUS) which differ in seasonality of upwelling intensity. We analyzed microzooplankton metazoan abundance and composition, which were sampled at onshore-offshore transects in austral summer and winter, and related it to abiotic parameters. Highest abundances, with standing stocks of 6-8 Mio ind./m^2 in the upper 100 m, were found in the nBUS in summer without a clear upwelling signal, whereas distinctly lower standing stocks (1-2.5 Mio ind./m^2) were sampled at most stations during upwelling in summer in the sBUS and in winter in both subsystems. The community in the nBUS in summer was dominated by adult copepods, while nauplii were more abundant at most stations during upwelling. Regarding the food, a dominance of dinoflagellates was detected at the northernmost station in the nBUS and at most stations in the sBUS in summer, while in winter all stations were dominated by diatoms. A likely explanation for the composition of metazoan microplankton could be that in summer, a matured community had developed as a result of previous upwelling events, while the upwelling in winter was fresh and the crustacean community was still developing as the dominance of nauplii implied.

S07-17202 Poster

Microzooplankton and their associations with other plankton

Claire H **Davies**[1], Ruth S. Eriksen[1], Luke Brokensha[2], Anthony J. Richardson[3,4,5], Frank E. Coman[3], Felicity R. McEnnulty[1], Anita Slotwinski[3], Mark L. Tonks[3] and Julian Uribe-Palomino[3]

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Microzooplankton play an important role in the food web being dominant grazers of primary production, whilst also being preyed upon by higher trophic levels. Within the microzooplankton there are a range of strategies employed to access food, such as obtaining nutrition from algal endosymbionts and networks of pseudopodial strands, and to avoid predation such as protective skeletons. Tintinnids, a type of ciliate, have been observed to form many associations with phytoplankton in the ocean, for example attaching diatom frustules to their lorica or in the grip of Chaetoceros dadyai setae. Reasons for these behaviours remain speculative and more research is needed to understand if these are strategies to increase motility, improve feeding opportunities and / or protection against predation. It is not always clear if the associations are positively or negatively impacting either of the species involved.

Using data from several Integrated Marine Observing (IMOS) surveys, the National Reference Stations (NRS), Southern Ocean Time Series (SOTS), the Continuous Plankton Recorder (SOCPR, AusCPR) and data from a research voyage in the Indian Ocean we can explore these associations. Notably, whilst using the same sampling methods we have seen more tintinnid / phytoplankton associations in the oligotrophic Indian Ocean than in the NRS samples where microzooplankton are an integral part of more complex food webs.

S07-17234 Poster

Seasonal variation in abundance of copepod nauplii in the western English channel, determined using a combination of fine mesh nets and FlowCam

Elaine **Fileman**[1], Yarrow Beckman[2], Chloe Jamin[3] and Eden Oldfield[4]

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While microzooplankton encompass both protozoa and metazoa, a significant proportion of microzooplankton studies tend to concentrate solely on the more prevalent protists. Nevertheless, metazoan nauplii play a vital role in marine ecosystems, actively consuming phytoplankton and bacterioplankton, and serving as the primary food source for larval fish and other invertebrate predators. Although copepod nauplii are the most numerous metazoan plankton in many marine ecosystems, they are frequently overlooked. This is due to the fact that they require different sampling techniques compared to their protozoan counterparts and they are challenging to identify. Consequently, their contribution to zooplankton communities is frequently underestimated. In this study we focus on the population structure of copepod nauplii collected using a vertical haul of a 63µm mesh net at a transitionally stratified time-series site, Station L4, located in the Western English Channel, UK. Weekly samples have been systematically collected since 2016, and using FlowCam to capture live images, copepod nauplii have been enumerated and identified to genus whenever possible. We have analysed the seasonal variation in nauplii abundance over the 8 year time-series, correlating it with available food, abundance of adult copepods, temperature and other environmental factors. The resulting data will be presented, providing valuable insights into copepod nauplii dynamics within this ecosystem.

S07-17311 Poster

Microzooplankton distribution and trends from long-term surveys around Australia

Ruth S. **Eriksen**[1,2,3], Claire H. Davies[1], Luke Brokensha[2], Frank E. Coman[3], Jason D. Everett[4,5,6], Felicity R. McEnnulty[1], Anita Slotwinski[4], Mark L. Tonks[4], Julian Uribe-Palomino[4], Anthony J. Richardson[4,5,6], Elizabeth Shadwick [1,2], and Kerrie Swadling [1,2]

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The value of plankton as indicators of marine ecosystem health is long established, as they respond rapidly to changes in oceanic conditions. Plankton communities in the oceans around Australia and Antarctica are routinely surveyed as part of the Integrated Marine Observing System (IMOS) Continuous Plankton Recorder (AusCPR and SOCPR) surveys. Plankton are also monitored at fixed locations through the IMOS National Reference Station (NRS) and Southern Ocean Time Series (SOTS) sites, which together form the core of Australia's only sustained marine plankton monitoring program. These species-level datasets can provide critical insights into plankton abundance, distribution and seasonal cycles from the tropics to the polar waters south of Australia.

In this poster we explore regional patterns and trends in the microzooplankton, focusing on the tintinnid ciliates. This unique group of unicellular grazers are themselves prey for a large variety of consumers, and some taxa have very restricted distributions such as estuaries, or sea-ice associations. The taxonomic diversity of the tintinnids is not well resolved in Australian waters, due to the highly plastic nature of the tintinnid lorica and the dearth of detailed coupled morphological and molecular studies in the region. This lack of foundational taxonomic knowledge hinders our understanding of the ecological role and biogeographical extent of the microzooplankton.

Session 8: Get it from the image: In situ imaging and spatially detailed observations of zooplankton for ecosystem studies

Convenors:
Klas Ove Möller (Germany), corresponding
Mark C. Benfield (USA)
Hongsheng Bi (USA)
Rob Campbell (USA)
Elaine Fileman (UK)
Adam Greer (USA)
Russell Hopcroft (USA)
Jules Jaffe (USA)
Julie Keister (USA)
David Kimmel (USA)
Jianping Li (China)
Dhugal Lindsay (Japan)
Jens Nejstgaard (Germany)
Sophie Pitois (Cefas)

Invited Speakers:
Lars Stemmann (Sorbonne Université, France)

Zooplankton serve as critical links in aquatic food webs and influence biogeochemical cycling. Because of this key trophic role, their spatial and temporal distribution, abundance, and behavior are used as indicators of ecosystem structure and function. Traditional net sampling of zooplankton, along with data processing, is labor intensive and requires significant taxonomic expertise. While imaging has a long history of application in zooplankton ecology, recent developments in in-situ optical imaging technologies and artificial intelligence/machine learning (AI/ML) are poised to revolutionize zooplankton ecology. New imaging systems are becoming more energy efficient and versatile, allowing for deployments on various observation platforms such as AUVs, Argo floats, and moorings. The rapid rise of AI/ML and significant advances in computing have led to an increased taxonomic resolution and specificity in zooplankton image processing. Furthermore, in situ observation of zooplankton allows distribution and abundance to be combined with information on organism traits, such as lipid reserves, egg clutch size, and body size, and datasets can be integrated with complementary high-resolution data streams, such as acoustics and eDNA, to reveal drivers of zooplankton population changes. In addition to this tremendous potential, technological developments also bring significant new challenges, such as ensuring quality control of massive image datasets, data storage and sharing, intercalibration of instruments, developing processing and classification algorithms, and extending observations through time by comparing with traditional sampling. We welcome contributions on all aspects of zooplankton imaging, including imaging system development, AI/ML data processing, comparisons to traditional net sampling, as well as efforts to integrate imaging with other high-resolution observational technologies. Presentations focusing on new emerging technologies should extend beyond the purely technical and aim to provide insights into ecological and biogeochemical processes. We aim to foster discussion on the advantages, shortcomings, and future needs that must be considered in order to apply imaging technology to zooplankton ecology.

S08-17228 Invited

Resolving scales of plankton ecology with in situ imaging

Lars **Stemmann**

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Understanding pelagic ecology and quantifying energy fluxes through the trophic web and from the surface to the deep ocean requires the ability to detect and identify all plankton and particles in situ and in a synoptic manner. An idealized sensor should observe both the very small living or dead particles such as picoplankton and detritus, respectively, and the meso- to macroplankton together with marine snow aggregates. Such an instrument would reveal an astonishing amount and diversity or morphotypes present in a parcel of water. Unfortunately, such sensors do not exist to resolve the full size range of plankton. However, complex interactions constrain the space, temporal, and size distributions of these objects in such ways that general rules can be inferred from the measurement of their optical properties and their silhouette. Recent technological developments allow for the in situ measurement of the optical properties, morphological traits, and computer assisted classification. These new sensors can be used as standalone or geared to various autonomous platforms to cover the full habitat of plankton. The format of the data allows collaborative research in a way such that synoptic surveys are possible by aggregating individual observation provided intercalibration and conformation to international standards. This presentation deals with plankton in situ observation to estimate rates, stocks and zooplankton communities from surface to the deep sea. Finally, we show the integration of the new data provided by these instruments with ML methods and mathematical models to produce plankton products for research and monitoring.

S08-17024 Oral

Imaging plankton probe (IPP): an AI-empowered underwater imager for long-term in situ observation of marine plankton

Jianping **Li**[1,2], Tao Chen[1,2], Zhenyu Yang[1,2], Guannan Guo[1,2], Zhenping Li[1,2], Peng Liu[1], Liangpei Chen[1], Guolong Wu[1], Zekai Zheng[3], Wenqi Ma[3], Jianping Qiao[3], Jiande Sun[3], Yuchun Pu[4], Qi Lin[4], Xuan Yu[4], Yinghao Cui[4] and Zhenghui Feng[5]

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This talk will report the new development of a novel underwater imager Imaging Plankton Probe (IPP) and its applications for in situ imaging of marine plankton and suspended particles. IPP achieves darkfield true-color imaging of planktonic particles in the size range of ~200μm-40mm, and features higher quality image yield and effective avoidance of underwater organism phototaxis during static deployment, thanks to its orthogonal laminar white light illumination. In addition, IPP has also been demonstrated very successful in biofouling control for protecting its underwater optics and housing with a record of more than six-month deployment in sub-tropical coastal waters without manual maintenance. IPP is not only equipped with machine learning-based algorithms for autonomous big image data analysis, its imaging capability is also greatly enhanced through a series of novel AI-enhanced methods including image super-resolution, depth-of-field extension and greyscale image colorization techniques. It has been tried to deploy on platforms including coastal rafts, surface buoy, and sea-bed landers along the East and South China Sea coast for long-term, high-frequency, continuous, and in situ monitoring of harmful plankton blooms and biodiversity in the past years. We expect this novel technology can be widely applied to enable various marine observational platforms for better supporting more comprehensive in situ plankton monitoring-based scientific research and marine ecosystem monitoring.

S08-17039 RecordedOral (ECOP)

The integrated Continuous Plankton Recorder (iCPR): using digital imaging in a new platform for global monitoring.

Pierre Hélaouët[1], Alex Nimmo Smith[2], Robert Camp[1], Kairan Cursons[1,2] and Nicolas Djeghri[1], Clare **Ostle**

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The Continuous Plankton Recorder Survey (CPR) survey is the longest running, most geographically extensive marine ecological survey in the world. Established in 1931, the Survey provides a basin-wide, long-term measure of the ecological health of our oceans. After 3 years of efforts, the CPR survey is now ready to routinely deploy its new iCPR sampler. Once equipped with our new bespoke module, any existing CPR body becomes an iCPR sampler benefiting from the latest innovations in terms of sensors (SST, Conductivity, Fluorometry), satellite geolocation and Artificial Intelligence (AI) applied on digital imagery. iCPR samplers are using vessel traffic data to drastically increase the precision of the data collected while retaining the consistency of a traditional CPR. To host a variety of sensors, the iCPR is using two impellers harvesting the energy generated by the water flowing through the sampler while being towed by a ship. Most importantly, our iCPR is equipped with a bespoke holographic camera able to generate precise digital images of the plankton encountered by the sampler. To handle those data, we are developing an ocean particle image analysis toolbox able to 1) transform raw holograms into annotated images, 2) do a series of automatic measurements on all Particles of Interest (POI) and 3) automatically classify the POI using AI. By combining high-throughput digital image analysis with in situ environmental measurements and satellite data, the CPR survey is now ready to closely interact with the scientific community to develop new ecological metrics.

S08-17064 Oral (ECOP)

Spatial segregation between cyclopoid and calanoid copepods in the Yellow Sea

Dai **Liu**[1], Zhonghua Cai[1] and Hongsheng Bi[2]

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Copepods play a pivotal role as secondary producers in marine ecosystems, making it essential to understand carbon and energy flow within these environments. Traditional studies on copepods have faced limitations due to sampling resolution and often overlooked the intricate interactions and ecological niche distinctions among different copepods. Recent advances in underwater plankton imaging systems, combined with cutting-edge AI technologies for rapid plankton image recognition, have presented an unprecedented opportunity to delve into the spatial interactions among diverse planktonic organisms. In this study, we employed the PlanktonScope to investigate the high-resolution spatial distribution of copepods in the coastal waters of Qingdao. We utilized fixed station sampling and continuous transect sampling techniques. The Mask R-CNN object detection and recognition system was employed for identifying, classifying, and measuring the body length of copepods. Results revealed that there was a clear spatial separation between calanoid and cyclopoid copepods. Calanoid copepods dominated in nearshore areas, whereas cyclops copepods exhibited a higher proportion in offshore regions. Results from continuous transect sampling unveiled a gradient in copepod abundance, suggesting that different copepod species prefer different environments. Regarding body length distribution, both calanoid and cyclopoid copepods displayed a normal distribution within their respective high-abundance areas. Notably, there were often more large individuals when one type of copepod dominates over the other type. When they overlapped, we observed a greater number of small calanoid and longer cyclopoid individuals, potentially indicating competition between the two species.

S08-17065 Oral (ECOP)

New Horizons: Autonomous assessments of zooplankton, their potential prey and predators via Zooglider

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Unlike towed bodies that require research vessel support, ocean gliders have the advantage of full autonomy and lack of mechanical connection to surface vessel motion. They also avoid challenges associated with attachment to the seafloor. These characteristics greatly facilitate imaging of zooplankton in situ, in natural postures, with minimal hydrodynamic disturbance. Yet gliders also permit interactive remote communications for adaptive sampling. The SIO Zooglider employs a bottom-avoidance algorithm, permitting it to autonomously traverse regions of abrupt seafloor topography such as submarine canyons and seamounts. Zooplankton (including metazoans and larger protists) and marine snow are imaged with a shadowgraph Zoocam employing a telecentric lens. Advanced Machine Learning Methods, building on Transfer Learning experiments, are currently used to classify 58 categories of images. Acoustic backscatterers are insonified at both 200 and 1000 kHz, then the size distribution of acoustic backscatterers (spanning zooplankton to fish) is reconstructed using DWBA backscattering models parameterized from Zoocam images. A hydrophone records vocalizations by marine mammals, fishes, as well as other components of the ambient soundscape. These, and related measurements, permit assessment of diverse zooplankton organisms in natural postures in situ, coincident with measures of their potential prey (approximated from Chl-a measurements as well as images of marine snow), predators (including carnivorous zooplankton, fish, and marine mammals), and the ambient hydrographic field. We will illustrate examples of unanticipated phenomena recorded by Zooglider from deployments in the Western Mediterranean Sea (BIOSWOT-Med region) and different hydrographic conditions and bathymetric provinces of the California Current System (CCE-LTER region).

~~**S08-17068 Oral (ECOP)**~~ CANCELLED

~~**Impacts of typhoon on zooplankton in the southwestern coast of Guangdong, P. R. China from the Continuous real time zooplankton data from PlanktonScope**~~

~~Jialin **Zhang**, Zhonghua Cai, Jian Zhao, Hongsheng Bi~~

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~~With the increasing global climate change, typhoon, as a climatic phenomenon with significant impacts, has exerted far-reaching impacts on the marine ecosystem in southern China coasts. This study examines the impacts of typhoons in 2021-2022 on zooplankton in Yangjiang coast, the southwestern coast of Guangdong using real time plankton data collected by PlanktonScope. We developed a deep learning based plankton recognition and enumerating system. Environmental variables were also collected in the same location.~~

~~The results showed that typhoons have a substantial impact on the coastal environment in the Yangjiang area, often leading to noticeable fluctuations in temperature, elevated turbidity, and significant shifts in salinity levels during these weather events. The significant change in salinity reveals a major change in water masses that may have been caused by the typhoon. The significant increase in turbidity reflects the strong mixing effect of the typhoon on the suspended matter in the water column. Abundances of different zooplankton groups varied differently during typhoon periods depending on different water masses. We hypothesize typhoons originating from the east tend to transport greater quantities of low-salinity water masses from the Pearl River region, resulting in an elevated presence of gelatinous zooplankton and copepods, whereas typhoons from the south transport offshore water masses, resulting an increase in salinity and reduction in most plankton groups.~~

S08-17076 Oral (ECOP)

Real time identification and reporting of plankton using Edge AI

Robert Blackwell[1], Hayden **Close**[1], James Scott[1], Sari Giering[2], Mojtaba Masoudi[2], Phil Culverhouse[3], Julian Tilbury[3] and Sophie Pitois[1], Noushin **Eftekhari**

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The Plankton Imager (PI) is a high-speed line-scan camera images all particles continuously in a through-flow sampling system. When connected to the water supply of a research vessel, the PI can thus image zooplankton continuously as the ship is underway, capturing 100s of images per second; Too many for a human to classify, too many to transmit using satellite network and too many to save to a disk. Yet, the high frequency nature of the instrument means it can provide a description of the zooplankton at unprecedented spatial resolutions. We present an automated, low cost, end-to-end, reproducible analytical pipeline for data intensive plankton research. We implemented a deep learning classifier, deployed on Edge-AI, that discriminates copepod from non-copepod and detritus with a high level of confidence. Processing images near to the source of collection allows for summary results (e.g. changes in plankton abundances and mean size) to be sent to a terrestrial digital dashboard in near real-time. Images are also stored, and disk-shipped to a cloud environment for further processing and analysis.
We show some applications of using high resolution plankton data with a low taxonomic resolution and we discuss how further development in data analytics tools could open the door to a new era of pelagic research and understanding of the role of zooplankton within the ecosystem.

S08-17086 Oral

Real time plankton monitoring in the Chesapeake Bay

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Plankton play a vital role in marine food webs, and monitoring plankton is essential for understanding their dynamics and underlying processes. Underwater imaging in coastal waters represents unique challenges in both imaging systems and image recognition due to high turbidity and complex physical environments. At the research pier of the Chesapeake Biological Laboratory, we deployed PlanktonScope to collect in situ, high-frequency, real-time plankton observations. The monitoring location was influenced by both Chesapeake Bay water and riverine water from the Patuxent River. To comprehend this high-frequency plankton time series, a state-of-the-science hydrodynamic and water quality model, based on an unstructured Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM) was developed to examine the impacts of different water sources on plankton. The results indicate that the study site was primarily affected by riverine water in the spring, characterized by a large copepod population, specifically Eurytemora. Conversely, during the summer, the monitoring site was predominantly affected by the Chesapeake Bay water. Our study illustrates that integrating real-time plankton data and numerical model can offer a robust, holistic view of the pelagic ecosystem's status across a broad range of spatiotemporal scales. The in-situ imaging systems like PlanktonScope hold promise as valuable tools for near real-time plankton monitoring and deepening our understanding of plankton dynamics.

S08-17110 Oral (ECOP)

Fine-scale spatial patterns of gelatinous zooplankton in the Northern Gulf of Alaska

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Understanding gelatinous zooplankton is challenging due to the inherent variability and complexity of the marine environment, further compounded by the limitations of conventional sampling methods. To address these challenges, we are leveraging recent advances in imaging technology and computing power by deploying an In Situ Ichthyoplankton Imaging System Deep-Focus Particle Imager (ISIIS-DPI), a towed vehicle capable of collecting vast amounts of high-resolution imaging and oceanographic data. Using a semi-convolutional neural network (sCNN), our analysis pipeline automates identification of zooplankton images to expedite processing time. We have deployed our ISIIS-DPI on 5 cruises over a 3 year period, covering over 800 kilometers during transects in the Northern Gulf of Alaska (NGA). The massive spatial coverage of this work allows us to describe fine-scale distributional patterns of gelatinous zooplankton and their associations with surrounding biophysical drivers. In the NGA, and many other ocean systems, ctenophores are often undersampled and poorly studied due to the limitations of traditional sampling methods. Here, we show that ctenophore aggregations are concentrated around frontal features, and present first records in the NGA of previously undetected species. These novel datasets demonstrate the prominence of ctenophores in the NGA, improving our understanding of their abundance and distribution patterns in the context of their oceanographic environment. Our adaptation of in situ imaging and machine learning technologies presents the opportunity to more accurately represent the role of gelatinous zooplankton in marine ecosystem function.

S08-17128 RecordedOral (ECOP)

Combining Human and Artificial Intelligence to Classify and Quantify Zooplankton

Ankita Ravi **Vaswani**[1], Tobias Schanz[2], Katharina Kordubel[1], David Greenberg[2] and Klas Ove Möller[1]

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State-of-the-art underwater imaging systems offer unprecedented opportunities to observe billions of individual zooplankton in their natural habitats at high spatiotemporal resolution. To unlock their full potential, we require new approaches to data analysis that go beyond taxonomic classification to quantify functional traits and biological phenomena from images. However, annotating relevant characteristics of organisms is labor-intensive, and typical approaches based on manual inspection and annotation cannot scale to the large datasets generated by new imaging technologies. We demonstrate a data workflow combining multiple, existing open-source frameworks and libraries that allows domain specialists to apply AI-based image classification and segmentation to meaningfully analyze large amounts of in situ image data. Our workflow allows multiple simultaneous users to annotate images and examine CNN predictions in an intuitive, feature-rich, web-based graphical interface, without requiring users to install software or download image datasets. We use our workflow to compare the results of fully-supervised and semi-supervised ML paradigms, and to further compare active learning and transfer-learning approaches on the overall and class-specific accuracies of image classification in a large plankton image dataset. We further demonstrate the use of certainty measures associated with CNN predictions to find rare classes in highly imbalanced datasets. Unusual classes and traits are also detected by applying outlier detection algorithms in the feature space of our supervised and unsupervised CNN output layers. We foresee that these tools will enable new avenues of investigation in aquatic research, ecosystem modelling and global biogeochemical flux estimations, revealing previously inaccessible relationships between species biodiversity, zooplankton traits and seasonal variations in environmental conditions.

S08-17147 Oral (ECOP)

Performance of a plankton imaging system mounted on a profiling glider for censusing zooplankton in threatened predator habitat

Natasha J **Hynes**[1], Christian Reiss[2], George R. Cutter Jr.[2], Jude van der Meer[3] and Kimberley TA Davies[1]

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Since 2010, the Bay of Fundy, Canada, has experienced an oceanographic regime shift that has altered the planktonic community in the water column. Some planktivore predators in this area, including the critically endangered North Atlantic right whale, have declined as a result. Sufficient time-space sampling resolution is needed to characterize and monitor the zooplankton community in this region and help explain these changes. Sampling with autonomous vehicles has proven to be a critical approach to achieving this high time-space sampling resolution. This project aims to develop an application for a Slocum glider-mounted shadowgraph camera system (Williamson & Associates, Seattle, WA) to describe the zooplankton community from images collected in the outer Bay of Fundy. In September 2022, three day/night deployments collected nearly 37,000 shadowgraph images in a deep ocean basin. A MultiNet Midi and Underwater Vision Profiler 6 (UVP6) collected biological samples and image/particle data, respectively, in tandem with glider deployments in a ground-truthing experiment. Shadowgraph images were annotated using Video and Image Analytics for Multiple Environments (VIAME). This talk will present inter-instrument comparisons of taxonomic composition, concentration and vertical distribution to quantify the performance of the shadowgraph camera prototype. This project supports the goal of adding shadowgraph cameras to a fleet of gliders operating in Atlantic Canada to monitor the zooplankton community concurrently with their large whale predators to inform marine conservation efforts.

S08-17192 Oral (ECOP)

Deep focus-extended darkfield imaging for in situ observation of marine plankton

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Darkfield imaging can achieve in situ observation of marine plankton with unique advantages of high-resolution, high-contrast and colorful imaging for plankton species identification, size measurement and abundance estimation. However, existing underwater darkfield imagers have very shallow depth-of-field, leading to inefficient seawater sampling for plankton observation. We develop a data-driven method that can algorithmically refocus planktonic objects in their defocused darkfield images, equivalently achieving focus-extension for their acquisition imagers. We devise a set of dual-channel imaging apparatus to quickly capture paired images of live plankton with different defocus degrees in seawater samples, simulating the settings as in situ darkfield plankton imaging. Through a series of registration and preprocessing operations on the raw image pairs, a dataset consisting of 55 000 pairs of defocused-focused plankter images have been constructed with an accurate defocus distance label for each defocused image. We use the dataset to train an end-to-end deep convolution neural network named IsPlanktonFE, and testify its focus-extension performance through extensive experiments. The experimental results show that IsPlanktonFE has extended the depth-of-field of a 0.5× darkfield imaging system to ~7 times of its original value. Moreover, the model has exhibited good content and instrument generalizability, and considerable accuracy improvement for a pre-trained ResNet-18 network to classify defocused plankton images. This focus-extension technology is expected to greatly enhance the sampling throughput and efficiency for the future in situ marine plankton observation systems, and promote the wide applications of darkfield plankton imaging instruments in marine ecology research and aquatic environment monitoring programs.

S08-17256 Oral (ECOP)

Resolving fine-scale zooplankton community structures in a dynamic frontal zone in the North Sea with automated in situ imaging

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The North Sea Doggerbank has highly dynamic frontal zones where upwelling of nutrients and small-scale physical heterogeneity lead to a complex marine food web in which zooplankton has an important but understudied role. The region serves as a historical and present fishing area, as well as a feeding ground for sea birds and marine mammals and is under multiple anthropogenic stressors. An In Situ Ichthyoplankton Imaging System (ISIIS) was deployed in spring 2023 at transects covering transition zones from the shallow bank to deeper surrounding waters to provide fine-scale spatial resolution of changes in the zooplankton community. We applied a fully automated image analysis pipeline, consisting of a segmentation procedure able to successfully detect Regions of Interests (RoIs) in the generally turbid waters characteristic for this region. For RoIs classification, we constructed a new public learning set of manually labelled images from the study area that was further enriched by images from existing training libraries on which a Convolutional Neural Network named EfficientNetV2S, that was selected in a previous study, was trained. Differences in hydrography along depth transitions created contrasting zooplankton communities mainly consisting of copepods, chaetognaths, Noctiluca scintillans, dense patches of long-chain diatoms, and the previously understudied groups of Appendicularia and hydrozoan medusae. This work was part of a holistic sampling campaign of the food web that coincided with unprecedented temperatures caused by a marine heatwave.

S08-17257 Oral

Fine-scale zooplankton distribution in two contrasting southern Greenlandic fjords and its relation to environmental factors

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Greenlandic fjord systems discharge melt water from the Greenland Ice Sheet to the ocean. Recent studies show that the hydrography, nutrient concentration, turbidity, and primary productivity differ between fjords that are fed by marine- and land-terminating glaciers, with potential consequences for the fjord ecosystem. Here, we present results from an in-situ imaging study with the shadowgraph In-Situ Ichthyoplankton Imaging System (ISIIS), coupled to a CTD and environmental sensors, of two Greenlandic fjords that are fed by such contrasting glacier inputs. Undulating transects (0-300m water depth), yielding a total of >150,000 full frame images, showed strong vertical and horizontal gradients in environmental and biological variables. Shelf stations were clear, had low chlorophyll-a concentrations and showed high numbers of Appendicularia, often visible in their mucous feeding nets, and discarded mucous nets. Further into the fjords, zooplankton in the surface 50m was dominated by hydrozoans, ctenophores and small copepods and showed high concentrations of aggregates and long-chained diatoms. Deeper parts of the water column were clear and were dominated by large copepods and Chaetognaths. The gradients in zooplankton community composition and abundance will be related to various proxies including hydrography, oxygen, water column visibility (i.e., risk of visual predation), chlorophyll-a concentration, primary production (measured directly with light curves based on Fast-Repetitive-Rate-fluorometry and light extinction), to identify the controlling factors and relate these to the present and future conditions of Greenlandic fjord systems.

S08-17274 Oral

Modular shadowgraph imaging for resolving zooplankton distributions in diverse field and mesocosm settings

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Shadowgraph imaging has been successfully used for larger and relatively rare zooplankton taxa (<100 ind. m^{-3}), such as larval fishes and gelatinous animals, that require large sample volumes to resolve distributions. However, such imagers have typically included large towed vehicles deployed from research vessels, introducing high costs and limiting where they can be deployed. Here we demonstrate that versatile configurations of shadowgraph imaging, including a hand-held system and compact modular vehicle (along with customizable software), allow for tailoring sampling to address new scientific questions in both marine and freshwater settings. The modular shadowgraph systems encompass a suite of possible architectures, designed for adapting the imaging depth of field, acquisition rates, sensor configuration, and deployment method to fit a wide range of sampling programs, including mesocosms and shallow waters, with high vertical resolution (5 cm) and adequate taxonomic capabilities for >0.5 mm organisms. To complement the in situ shadowgraph systems, a benchtop system provides an interactive and targeted approach to observe and quantify zooplankton behaviors and optical properties in the field. Video footage from the benchtop system generates thousands of regions of interest min^{-1} for target organisms with variable orientations and swimming postures. When used in conjunction with in situ imaging, the benchtop system can build large, robust machine learning training libraries targeted towards rare zooplankton, which often includes the larval stages of economically valuable taxa. These modular hardware and software components increase affordability and versatility, while broadening the scope of scientific questions addressed by plankton imaging systems in aquatic ecosystems.

S08-17277 Oral

Copepod and euphausiid abundances in the southeastern Bering Sea USA estimated from the PlanktonScope shadowgraph imaging system

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Copepods and euphausiids are key components of the Bering Sea food web providing forage for commercially important fish, seabirds, and mammals. Information about these populations has historically been estimated from bongo nets and is used to inform an ecosystem-based fisheries management process. The net-based approach has some well-known drawbacks that include euphausiid avoidance of nets and the significant time and expertise needed to process samples. The advancement of in situ imaging technology and data processing show promise as an alternative to net sampling. Here we present results of three, night-time, shadowgraph image system (PlanktonScope) deployments in the southeastern Bering Sea. Our goals were to estimate copepod and euphausiid abundance near Bering Canyon and on the nearby shelf to determine if these locations differed, particularly for euphausiids that have been hypothesized to be delivered onto the shelf via advection from canyons. We found high euphausiid abundances in eastern (18 ind m^{-3}) and western (12 ind m^{-3}) Bering Canyon, with euphausiids nearly absent on the shelf (0.25 ind m^{-3}). Copepod abundances were also higher in the eastern (3004 ind m^{-3}) and western (2385 ind m^{-3}) Canyon and lower on the shelf (1924 ind m^{-3}). Mean copepod size (total length) was also higher in the canyon (580-610 µm) than over the shelf (460 µm). We plan to compare these estimates to net samples taken concurrently, once those data have been processed. These early results suggest the PlanktonScope image system and data processing pipeline is able to provide rapid estimates of zooplankton information critical to the management process.

S08-17332 Oral

Remote sensing of zooplankton surface patches – possibilities and challenges

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Patchy zooplankton distributions are notoriously difficult to map using traditional ship-based techniques. Some zooplankton (Calanus, krill species) posess the pigment astaxanthin that we have shown can be sensed by ocean colour remote sensing. Reprocessing of satellite (VIIRS) data in 2018 render our 2019 results on the remote sensing of zooplankton less certain but using an updated approach we can identify surface patches of Calanus in the Norwegian Sea based on remote sensing.
The updated approach involves standardizing satellite eRGB imagery and radiative transfer modelling to identify reflectane anomalies. This way, surface concentrations of 80,000-150,000 individuals m^{-3} are estimated, which are higher than obtained by most net sampling. However, acoustic estimates derived from a silent surface glider (Sailbuoy), yield surface concentrations in the same range during periods of cloud cover and calm seas. We discuss the challenges related to remote sensing and estimating correct surface concentrations using other approaches.

S08-17339 Oral (ECOP)

Influence of the Amazon River Plume on plankton distribution in Western Tropical Atlantic

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The Western Tropical Atlantic (WTA) is a dynamic area influenced by strong western boundary currents and the Amazon River Plume (ARP). The circulation and huge continental input increase planktonic production in the open waters through the North Brazilian Current Retroflection (NBCr) system. Therefore, this study aims to quantitatively investigate the horizontal and vertical abundance distribution, biovolume and biomass of zooplankton and particles along the ARP continuum. Zooplankton samples and UVP5 profiles were obtained along the ARP during two oceanographic cruises, Camadas Finas III and Meteor 174, during and outside the NBCr periods, respectively. Zooplankton samples were digitalized with ZooScan and the images were analyzed for obtention of size parameters used to estimate biovolume (mm^3m^3) and biomass (µgC). Normalized biomass size spectra (NBSS) were used to assess productivity and trophic relationships. The horizontal carbon transport was estimated for each current sector influencing the area. Statistical analyses were conducted to compare the ARP distribution zones (inner shelf waters, outer plume, and oceanic waters), regarding biological and physical-chemical parameters. Preliminary results showed an increase in zooplankton abundances ($ind.m^{-3}$), biovolume, biomass, and carbon horizontal transport values in the region under ARP influence with high values on the NBCr and North Equatorial Countercurrent (NEEC) sectors. The NBCr transports 1.07 $ktC\ d^{-1}$ from the coast to oligotrophic WTA oceanic areas, where the NECC transports 1.27 $ktC\ d^{-1}$ eastward. Our data evidences the ARP control on costal-oceanic gradient regarding planktonic productivity, highlighting the Amazon coastal areas importance as a source of planktonic organisms for open ocean.

S08-17376 Oral (ECOP) Recorded

Optical and acoustic based sampling of zooplankton with autonomous vehicles: Challenges and future perspectives

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Marine biodiversity faces escalating threats, necessitating robust methods for assessing diversity, distribution, and abundance. Traditional zooplankton net sampling is time-consuming, taxonomically demanding, and constrained in spatiotemporal resolution. Autonomous vehicles, equipped with echosounders and imaging systems offer promising solutions for real-time and high-resolution sampling. To provide input for autonomous sampling strategies, this study explores zooplankton avoidance behavior in response to sensor-equipped vehicles by employing a stealthy Unmanned Surface Vehicle (USV) collaborating with an Autonomous Underwater Vehicle (AUV). Additionally, we assess the synergy of imaging systems and acoustics to differentiate between zooplankton classes. Field experiments in Kongsfjorden, Svalbard, reveal essential insights. The USV conducts reconnaissance missions to identify zooplankton scattering layers, providing target locations for the AUV. Acoustic data and Silhouette Camera (SilCam) images capture the impact of the AUV on scattering layers, enhancing our understanding of payload sensor and platform capabilities. Furthermore, we examine the symbiotic enhancement of taxa estimations through the integration of particle imaging data and EK80 echosounder data. The AUV's interaction with the scattering layers induced changes visible in the acoustic backscattering strength and the layer distribution. SilCam images provided zooplankton abundance estimates and size distribution profiles. Dual-frequency analysis of acoustic data provides insights in zooplankton abundance and behavior, while plankton net and water samples for eDNA facilitate species identification. Challenges such as zooplankton avoidance behavior and calibration uncertainties are addressed through a multimodal approach, combining strengths of various measurement methods. This study lays the groundwork for autonomous solutions to provide more efficient and informative zooplankton sampling.

S08-17425 Oral

Image-based Zooplankton and Phytoplankton survey records in South Florida Waters Contributed by the U.S. Marine Biodiversity Observation Network Program (MBON)

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Sustained observations of plankton are critical to understand how environmental drivers and biological interactions shape trophic structure, food web dynamics, and ultimately the distribution and abundance of living marine resources. This study examined image-based plankton surveys in south Florida waters as part of the U.S. Southeast Marine Biodiversity Observation Network effort to evaluate phytoplankton and zooplankton diversity. Five field campaigns aboard the R/V Walton Smith (U. Miami) were carried out between December of 2022 and July of 2023 in which plankton imagery profiles from ~70–90 stations were collected in the Florida Keys National Marine Sanctuary and surrounding waters. We used a Continuous Particle Imaging and Classification System (CPICS) mounted on a CTD rosette. Image segments (Regions of Interest; 6,756) were uploaded and classified on EcoTaxa 2.6 to quantify occurrences of chain diatoms, Trichodesmium spp, dinoflagellates, copepods, radiolarians, polychaetes, Appendicularia spp, echinoderms, and gelatinous species. Plankton occurrences were matched to satellite-derived seascapes (a product that provides dynamic biogeographic classification of water masses). Three seascape classes dominated sampling events: Tropical/Subtropical Transition (T/S-T: 15%), Tropical Seas (TS: 20%), and Warm, Blooms, High Nutrients (WBHN: 51%). Results show differentiation in plankton distributions between seascape categories and seasonal variability in species composition within seascapes. Chain diatoms occurrences, for example, varied between < 10% to ~ 75% in the TS class, and the highest diversity of plankton was observed in the WBHN class. Satellite seascapes can provide a biogeographic framework to evaluate spatio-temporal shifts in plankton communities to support management decisions in marine protected areas.

S08-17048 Poster (ECOP)

A promising approach to counting heaps of very small things

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Thecosome (shelled) pteropods are regarded as early responders to climate change due to the fragile, aragonite shells they produce that are highly susceptible to dissolution linked to ocean acidification. Pteropods incubated under predicted future levels of ocean acidification and warming have shown a range of adverse responses, including a decrease in the proportion of eggs developing to advanced embryogenetic stages. This is bound to have long-term ecological ramifications related to population stability and recruitment.
During their lifetime, female thecosomes spawn tens of thousands of transparent eggs which are embedded on ribbons within gel matrix egg masses. Challenges in estimating their fecundity are related to the high number and tiny size of the eggs. Manually counting them can be time consuming and dissection can induce stress. These challenges may be minimized with the use of image analyses and machine learning platforms. Reliably predicting the number of eggs via data imaging techniques were developed and tested in this study.

S08-17077 Poster (ECOP) (POSTER->ORAL)

Tri-dimensional characterization of plankton along the South Brazilian Shelf: from images to organisms

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Plankton communities compose the base of the food web, linking the primary producers to the higher trophic level's consumers, such as marine birds and mammals. Its distribution affects the entire marine ecosystem up to the economic sectors that explore shelf areas, especially at South Brazilian Shelf (SBS). However, studying planktonic organisms involves the understanding of their dynamics in marine ecosystems, since they have limited natatory function, a wide distribution in the world's ocean, as well as its vast variety of taxonomy and size. In this study we combined the spatial data resulting from nearly 100 vertical hauls of the Light frame On-sight Key species Investigation (LOKI) and most relevant environmental variables estimated during four oceanographic surveys to understand the phyto- and zooplankton interactions and distribution along the SBS. Preliminary suggests a heterogeneous spatial distribution of phytoplankton and zooplankton on the shelf. Horizontally, the coastal bloom of phyto- generated during the upwelling spreads towards the shelf. Concurrent with the dispersion from the coast, the phyto- distribution through the water column seems to be simultaneously influenced by the zooplankton consumption. New developments that are foreseen in the coming years include (1) the standardization of the images into interoperable data format, (2) application of different models to simulate phyto- and zooplankton dynamics and calculate the relative contribution of the bottom-up and top-down drivers on phytoplankton dynamics.

S08-17200 Poster (ECOP)

Basin-scale underway quantitative survey of surface microplankton using affordable collection and imaging tools deployed from Tara

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World ocean plankton quantitative biodiversity data are still severely limited due to the high cost and logistical constraints associated to oceanographic vessels and collection/ analytic devices. Here, we report the first use of an affordable and open-source plankton collection and imaging kit designed for citizen biological oceanography, composed of a high-speed surface plankton net, the Coryphaena, together with a portable in-flux automated imaging device, the PlanktoScope. We deployed this kit in December 2020 along a latitudinal transect across the Atlantic Ocean on board the schooner Tara, during the first Leg of her 'Mission Microbiomes'. The citizen-science instruments were benchmarked and compared at sea to state-of-the-art protocols applied in previous Tara expeditions, i.e. on-board water pumping and filtration system and the FlowCam to respectively sample and image total micro-plankton. Results show that the Coryphaena can collect pristine micro-plankton at speed up to 11 knots, generating quantitative imaging data comparable to those obtained from total, on-board filtered water, and that the PlanktoScope and FlowCam provide comparable data. Overall, the new citizen tools provided a complete picture of surface micro-plankton composition, biogeography and biogeochemistry, opening the way toward a global, cooperative, and frugal plankton observatory network at planetary scale.

S08-17232 Poster

The Automated Plankton Imaging and Classification System (APICS): a dual-camera sensor designed for remote operation in the Western English Channel

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Microscopic analysis has traditionally been used to identify and enumerate different types of plankton present in water samples collected from remote locations using research vessels. Reliance on ships for water sample collection and manual processing for determination of taxonomic abundance not only leads to substantial expense but also greatly constrains the speed at which data can be gathered and analysed. This makes the study of short-period dynamics logistically impossible using traditional techniques.

To address this challenge, at Plymouth Marine Laboratory, we are constructing a bespoke Automated Plankton Imaging and Classification System (APICS). This innovative system incorporates two autonomous submersible camera units - an Imaging FlowCytobot and a Plankton Imager - which are fixed onto a buoy that will be deployed remotely at station L4, a marine biodiversity reference site situated in the Western English Channel, UK. The cameras will image a broad size spectrum of planktonic groups ranging between ~5 µm to 10 mm. By integrating the collected images with machine learning algorithms and an efficient data processing pipeline, the collection and processing of data will occur at speeds vastly surpassing that of manual procedures. Operating costs will be significantly reduced and through the use of renewable energy to power the equipment, and the reduced reliance on research vessels, the project supports the ambition of moving towards net zero oceanography. Here we provide a description of APICS, the design and engineering challenges it raises, and the types of scientific question it will enable researchers to address.

S08-17246 Poster

Using frugal tools to study plankton at large scale: examples from Plankton Planet and future deployments

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Plankton are essential in marine ecosystems and it is essential to monitor their population at different scales of space and time to understand their changes associated with environmental constraints. Yet studying plankton usually requires expansive platforms (boats), instruments (microscopes) or expertise (taxonomic) to efficiently sample and analyze plankton communities. The Plankton Planet association had been created to tackle such problematic and to give raise to protocols and methodologies allowing Seatizens sailors to deploy and collect informative plankton samples at low coast but large scale. From this association emerged several tools the fluidic microscope "Planktoscope" and the inverted observation microscope "Curiosity" that are now available. Together with the online platform EcoTaxa, which allow efficient image treatment and shared taxonomic expertise, they allow efficient and FAIR collection of plankton community composition and outreach, unlocking constraints to achieve globally consistent quantitative observations of planktonic ecosystems We review here the past deployments and use of those two instruments, do demonstrations of their use depending on technical possibilities, and give an overview of future deployments already planned.

S08-17284 Poster (ECOP) CANCELLED

~~**Is zooplankton image acquisition an effective tool for monitoring the South Georgia pelagic ecosystem?**~~

~~Cecilia M. **Liszka**[1], Mark Belchier[2], Alison Cleary[1], Victoria Dewar-Fowler[1], Carrie Marell-Gunn[1], Marianne Wootton[3], Geraint A. Tarling[1]~~

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~~The South Georgia (SG) zooplankton community is a critical component of the Scotia Sea ecosystem characterised by high productivity and biomass. Establishing a pelagic biodiversity baseline at SG is crucial to assess the stability of this system and its response to climate-related changes and species invasions. Zooplankton and ichthyoplankton are also key bioindicators of change since they have short life-cycles and rapid response times. However, monitoring through net sampling alone can be costly and may risk underestimating fragile or highly motile taxa. In a novel project designed to complement net-based taxonomy and develop a framework for ongoing ecosystem monitoring, we are deploying an Underwater Vision Profiler (UVP6-HF) on monthly repeat profiles at locations around the SG shelf, in conjunction with a fine-meshed vertical net, a coarse-meshed net trawl, and eDNA sampling. Here we present preliminary results from our first six months of image data acquisition, encompassing the transition from austral winter through spring and summer. We consider the potential for in-situ image data to generate reliable estimates of zooplankton abundance, biomass and carbon; and discuss the influence of seasonal transition on the accumulation of zooplankton biomass and trophic energy flow. Normalized biomass size-spectra (NBSS) provide an encapsulation of the zooplankton community, and we compare our UVP6 and ZooScan-based NBSSwith published NBSS models for the SG region based on net sampling, to explore the utility of imaging analysis in quantifying ecosystem change. Finally, we discuss some of the challenges, opportunities and future directions for zooplankton image analysis in this sub-polar region.~~

S08-17371 Poster (ECOP)

Influence of a downwelling process induce by an anti-cyclonic eddy, on the vertical structures and spatial distribution of Subarctic zooplankton communities.

Nicolas **Gosset**, Sünnje L. Basedow, Boris Espinasse and Zoé Koening

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Mesoscale eddies are dominant features in the world's oceans, including in the Norwegian Sea and are described as productivity hotspots. They play a crucial role in controlling the structure of marine planktonic communities and the transfer of particulate organic matter to depth. These eddies can influence zooplankton behaviour, physiology, and retention or dispersal of organisms. Eddies are mainly induced by seasonally wind forcing and interaction with largescale current circulation features. However, there is limited information regarding the eddyinduced changes in the zooplankton community and how communities are horizontally and vertically distributed. This study aims to explore the influence of downwelling, induced by a Northern Norwegian Sea anticyclonic eddy, on the vertical structures, spatial distribution, and size spectrum of zooplankton communities, down to 1000 m. The inherent hydrography and physical characteristics of the eddy are also investigated. The data collection includes Multinet sampling, satellite remote sensing (sea-level anomaly), Laser Optical Plankton Counter (LOPC), and an Underwater Vision Profiler (UVP6) mounted at the front of a Seaglider deployed within the eddy. This study contributes to enhancing our understanding of the biological importance of eddies and their role in the transport of zooplankton communities and biogeochemical cycles.

S08-17373 Poster (ECOP) CANCELLED

~~Fine and large-scale distribution of zooplankton and marine snow in the Iceland Basin and Iriminger Sea, observed by a Video Plankton Recorder~~

~~Sólrún **Sigurgeirsdóttir**[1,2], Ástþór Gíslason[1], Hildur Pétursdóttir[1] and Jörundur Svavarsson[2].~~

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~~[2]University of Iceland, Reykjavík, Iceland.~~

~~Zooplankton are important food sources for many fish species and other organisms in the mesopelagic layer. Spatial distribution of zooplankton has mainly been studied by using conventional nets that integrate abundance over relatively large intervals and therefore do not give very accurate information about the vertical distribution in the water column. There is limited previous information on how the vertical distribution of zooplankton is related to environmental factors on a fine scale in the Iceland Basin and Irminger Sea. By using Video Plankton Recorder (VPR), we obtain data on the vertical distribution of zooplankton and environmental variables on a fine spatial scale. This enables an assessment to be made of how environmental factors affect the distribution and abundance of zooplankton in the water column.~~

~~Marine snow plays a big role in carbon transfer. By sinking down the water column from the productive surface layer the marine snow transfers carbon to the deeper layers of the ocean. By combining data on abundance and size of marine snow particles with equations relating size of particles to sinking velocity an estimate of flux of marine snow can be estimated.~~

~~I will present results from two cruises that were conducted in the Iceland Basin, the Irminger Sea and along a transect over the Reykjanes Ridge.~~

~~This study is a part of the European project MEESO (Ecologically and economically sustainable mesopelagic fisheries) and contributes to its aims of understanding the abundance and distribution of organisms in the mesopelagic layer.~~

S08-17381 Poster

Characterization of zooplankton and marine snow dynamics in the Atlantic: insights from three BGC-ARGO floats equipped with Underwater Vision Profilers.

Lars **Stemmann**[1], Alexandre Accardo[1], Joelle Habib[1], Dodji Yawouvi Soviadan[1], Laetitia Drago[1], Myriam Beck[1], Alberto Baudena[1], Remi Laxenaire[2], Sabrina Speich[3], Rainer Kiko[1,4]

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The biological carbon pump (BCP) involves wide-ranging processes that contribute to carbon sequestration. Zooplankton can influence the BCP strength by altering particle production or through feeding on and fragmentation of sinking particles. Three BGC Argo floats equipped with Underwater Vision Profiler 6 were deployed in the Atlantic at the equator, off Angola and off South Africa to study the strength of these processes. The floats were recovered after ap. 1.5 years each. For the first time, all images were recovered to allow supervised and non-supervised sorting of plankton taxa and particle morphologies. Satellite data analysis was used to study the impact of mesoscale eddies and fronts on zooplankton and particle dynamics. The datasets show clearly different community composition across latitudes and seasons. The floats deployed at the Atlantic equator and off Angola showed a weak impact of advection allowing the interpretation of the observations in a 1D framework and the possibility to infer the sinking rate of marine snow. In contrast, the float deployed at 40°S showed a change in the composition of the plankton community and the marine snow associated with the eddy field. Because of this variability, the dataset cannot be interpreted as solely 1-dimensional, and vertical sinking cannot be disentangled from sub-mesoscale effects on the particle field. In fact, we show that during the productive season, intense particle export down to 600m depth occurs at the edges of cyclones and anticyclones probably as a result of intense vertical velocities. Hence, the data acquired by BGC floats analyzed in combination with satellite altimetry has proved to be an efficient tool to track upper 1000m ocean plankton and particles in contrasting situations and to evaluate their impact on biogeochemical fluxes.

Session 9: Impacts of zooplankton production and trophic interactions on fisheries recruitment in the ocean

(S9 and S12 merged under S9. Title is updated)

Convenors:
Lidia Yebra (Spain), corresponding
Hui Liu (USA)
Johanna Medellín (Chile)
Karyn Suchy (Canada)

Invited Speakers:
Gen Kume (Kagoshima University, Japan)

S9/S12 Merged Description

Sustainability of fisheries requires a better understanding of stock dynamics and resilience to climate and anthropogenic forcing. Zooplankton play a key role integrating variations at the base of the food web and transferring them toward higher level consumers including fishes. Thereby, zooplankton production and its variability in response to global change are highly relevant to fisheries production and ecosystem functioning. Understanding the impact of zooplankton production on fisheries recruitment is a crucial step needed to forecast stock response and resilience to environmental variability. Ultimately, the foundation of marine food webs, and subsequent trophic transfers, are essential for supporting higher trophic levels such as larval and adult fishes. The realized and predicted impacts of climate change on global fisheries are of high interest to the international community, and thus research aimed at understanding how climate change impacts different levels of the marine food web (e.g., microbial community, crustaceans, gelatinous grazers and predators, larval fishes) is of high importance. Advancement on these topics will enhance efficient incorporation of zooplankton production and trophic interactions into the ecosystem-based management of marine resources. This session will share and review the new information for understanding functional and structural roles of zooplankton production on fisheries trophodynamics and production. In particular, we encourage presentations and discussions using experimental, observational and modeling approaches linking zooplankton productivity to growth and survival of forage fish larvae and juveniles in their nursery grounds. We hope this session will bring out key questions about how zooplankton production and trophic web variability may impact fisheries recruitment and productivity and stimulate debate and foster international collaborations.

S09-17038 Invited

Predatory impacts on mesozooplankton of small pelagic fish larvae in the northern Satsunan area, southern Japan

Gen **Kume**[1], Hiroki Oba[2], Soushi Shiroyama[2], Taichi Shigemura[3], Kazuhiro Shiozaki[1], Mutsuo Ichinomiya[4], Tomohiro Komorita[4], Masafumi Kodama[1], Takafumi Azuma[1] and Toru Kobari[1]

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The northern Satsunan area, southern Japan is used as an important spawning and nursery ground for small pelagic fish (i.e., *Engraulis japonicus*, *Scomber japonicus*, *Scomber australasicus*, *Trachurus japonicus*). We estimated predatory impact on mesozooplankton of *E. japonicus* and *Scomber* spp. (*S. japonicus* and *S. australasicus*) larvae in the study area, which are most abundantly occurred in ichthyoplankton from winter to spring. Larvae and mesozooplankton were collected using the ORI and twin-type NORPAC nets at 15 stations in the mouth of Kagoshima Bay and adjacent area in 2021. To estimate predation impacts on mesozooplankton, food requirement was estimated for *E. japonicus* and *Scomber* spp. larvae. The weight-specific growth coefficients (Gw) were 0.19 d^{-1} for *E. japonicus* and 0.14 d^{-1} for *Scomber* spp. Based on the reported relationship between Gw and ingestion rate of the larval fishes, the daily rations were calculated to be 67.8% for *E. japonicus* and 51.6% for *Scomber* spp. of body dry weight d^{-1}. Predatory impacts of *E. japonicus* and *Scomber* spp. larvae on the production rate of mesozooplankton was estimated to be approximately 0.52–55.2% and 0.08–1.1%, respectively. Main preys are calanoid copepods and appendicularians for *E. japonicus* and *Scomber* spp. larvae, respectively. A clear diet niche segregation among species may enable to coexist in the study area.

S09-17032 Oral

A matter of size and season: insights into planktonic food-web dynamics in a temperate coastal ecosystem

Carolina **Giraldo**[1], Pierre Cresson[1], Kirsteen MacKenzie[1], Virginie Fontaine[1,2], Christophe Loots[1], Alice Delegrange[2] and Sébastien Lefebvre[2].

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Knowledge of the trophic structure and variability of planktonic communities is a key factor in understanding food-web dynamics and energy transfer from zooplankton to higher trophic levels. In this study, we investigated how stable isotopes of mesozooplankton species varied seasonally (winter, spring, autumn) in relation to environmental factors and plankton size classes in a temperate coastal ecosystem. Our results showed that spring is characterized by the strongest vertical and size-structured plankton food-web, mainly fueled by the phytoplankton bloom. As a result, spring displayed the larger isotopic niche space and trophic differentiation among species. On the contrary, both pelagic and benthic-derived carbon influenced low productive seasons (winter and autumn), resulting in more generalist strategies. Stable isotope mixing models were used to explore how different seasonal structures influenced the overall food web up to predatory plankton (i.e., mysids, chaetognaths, and fish larvae). Different feeding strategies were found in spring, with predators having either a clear preference for larger prey items (>1mm, for herring and dab larvae) or a more generalist diet (sprat and dragonets larvae). During low productive seasons, predators seemed to be more opportunistic, feeding on a wide range of size classes but in particularly smaller prey. Overall, the food-web architecture of lower trophic levels propagate upwards to carnivorous plankton including fish larvae highlighting important bottom-up processes.

S09-17040 Oral

Community structure of ichthyoplankton associated with advective mixing of the Kuroshio and its neighboring waters

Toru **Kobari**[1], Yusuke Manako[2], Airi Hara[1], Kaori Yamanoue[2], Rika Tanonaka[2], Takafumi Azuma[2], Yi-Chen Wang[3], Masafumi Kodama[1] and Gen Kume[2]

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The Kuroshio has been long thought to be disadvantageous for various fishes due to the low standing stocks of phyto- and zooplankton under the oligotrophic conditions throughout the year. Despite of a potential risk for survival, various fish larvae appear abundantly in the Kuroshio and its neighboring waters. Here, we report community structure of fish larvae associated with advections of Continental shelf waters (CW) and the Kuroshio (KW) based on multivariate analysis on their taxonomic compositions. 16 orders, 75 families and 449 groups were classified in the present study. Mesopelagic fishes more abundantly appeared in the KR than in the CW, while abundance of fish larvae was not different between the two areas. Non-Metric Dimensional Scaling and Analysis of Similarity demonstrated that the taxonomic compositions were different between the KR and CW. Based on Similarity of Percentages, representative families were Callionymidae, Bothidae, Labridae and Bregmacerotidae for the CW and Gonostomatidae, Myctophidae and Notosudidae for the KR. *Sigmops gracilis* and *Myctophum orientale* represented for the KW demonstrated positively correlations of their abundances to the ambient salinity, while no significant correlation was found for *Bregmaceros japonicus* and *B. nectanus*. Taxonomic compositions were similar at the three stations in the CW due to abundant appearance of the representative species advected from the KW. Considering mesozooplankton standing stocks in the KW equivalent to those in the CW, mixture of the advected waters from the CW or KW might stimulate biological productivity and biodiversity in the Kuroshio and its neighboring waters.

S09-17041 Oral

Trophic sources and pathways toward fish larvae under spring phytoplankton bloom in the neighboring waters of the Kuroshio

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Coastal sites neighboring the Kuroshio have been known as nursery grounds for early life stages of commercially important fishes. It is believed that their early growth and survival are supported by mesozooplankton biomass and production stimulated under spring bloom with large diatoms and dinoflagellates. However, since such diatoms and dinoflagellates are too large for small copepods predominating in the neighboring waters of the Kuroshio to ingest, general paradigm should be re-considered. Here, we explore trophic sources and pathways toward fish larvae in the coastal sites neighboring the Kuroshio based on metabarcoding analysis of gut content DNA for major taxonomic groups of mesozooplankton and fish larvae. We obtained 728,250 and 297,017 sequence reads of prey from gut content DNA of mesozooplankton and fish larvae, respectively. Mesozooplankton demonstrated that major prey was calanoids and the secondary prey were phytoplankton and gelatinous metazoans. Fish larvae ingested calanoids as major prey and gelatinous metazoans as supplementary prey. Both mesozooplankton and fish larvae showed that calanoids were the most frequently appeared prey and gelatinous metazoans was the second frequency. Trophic networks based on the prey composition and appearance frequency demonstrated that calanoids were the major nodes with multiple linkages among their prey and predators and gelatinous metazoans were the secondary node. These findings suggest that 1) calanoids were important hubs of trophic pathways toward fish larvae, 2) gelatinous mesozooplankton taxa strengthen trophodynamics in food web, and 3) trophodynamics toward fish larvae are not strongly dependent on spring phytoplankton bloom in neighboring waters of the Kuroshio.

S09-17085 Oral

Results of multi-year diet analysis project of young of the year Walleye Pollock (*Gadus chalcogrammus*) in the Western Gulf of Alaska, USA

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Walleye Pollock is a fish of high commercial value in the north Pacific Ocean.
As such, the environmental and biological factors that influence their early life history and contribute to overwinter survival and eventual recruitment are of considerable interest.
One factor that potentially plays a large role in pollock early life history is diet. For example, availabilty of low caloric (small or lipid poor copepods) versus high caloric (large lipid rich copepods and euphausiids) prey has a direct influence on growth rates and potential predator avoidance. Here we present a analysis of interannual variability within age-0 Walleye Pollock diets sampled every other year in the western Gulf of Alaska from 2003 – 2019. We tracked interannual shifts in diet composition using Prey-specific Index of Relative Importance (PSIRI), a metric used to determine prey importance within a diet. We then linked diet composition to a total energetic value per stomach. We then will explore the oceanographic and biological drivers of spatial and interannual variation in diet quality to further understand how changes in the Gulf of Alaska ecosystem affect conditions for juvenile pollock growth and survival.

S09-17108 Oral

In situ estimates of variability in trophic transfer efficiency in the subarctic NE Pacific from 2015-2018

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Trophic transfer efficiency (TTE) is a critical component shaping marine ecosystems insofar that small variations in TTE can propagate upwards, affecting food availability for higher trophic levels and fisheries production. Although originally defined in terms of production rates, for logistical reasons TTE has traditionally been calculated using biomass ratios in adjacent trophic levels, and long accepted to be about 10%. Despite decades of research, however, *in situ* estimates of TTE in marine ecosystems remain rare and estimates of spatiotemporal variability in TTE almost non-existent. Here, we present rate-based estimates of TTE from the subarctic NE Pacific, calculated as the ratio of crustacean zooplankton biomass production rates (mg C m^{-2} d^{-1}) estimated by the chitobiase method and net community production (NCP, mg C m^{-2} d^{-1}) derived from underway O_2/Ar mass spectrometry. Across four years and 68 sampling stations, TTE estimates ranged from 0.1 – 35%. Zooplankton diversity and community composition were assessed as factors driving variation in TTE. The abundance-based diversity metrics functional dispersion, functional divergence, and species evenness (as well as mixed layer depth) were significant predictors of TTE, and zooplankton community composition differed significantly between stations with high (>10%) and low (<10%) TTE. Characterizing drivers of spatiotemporal variability in TTE is key to constraining ecosystem models in order to forecast effects of changing ocean conditions on the energy available to support fisheries production.

S09-17123 Oral (ECOP)

Spatial patterns in zooplankton's nutritional potential for small pelagic fish revealed by fatty acid and community composition analysis

Carolin J. **Neven**[1], Alain Lefebvre[2], David Devreker[2], Guillaume Wacquet[2], Philippe Soudant[4], Paul Marchal[1], Fabrice Pernet[4] and Carolina Giraldo[1]

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Plankton plays a pivotal role in marine food webs. By grazing on phytoplankton, the main producer of essential fatty acids, zooplankton accumulates nutrients and energy, making them accessible to larger organisms, like small pelagic fish. Thus, the composition and nutritional value of plankton communities expectably influence abundance and condition of predators potentially creating spatial patterns of trophic transfer. In this study, we used phytoplankton and zooplankton community composition analysis, and fatty acid (FA) analysis applied to zooplankton and sardine (Sardina pilchardus), to investigate potential spatial patterns in the trophic transfer from plankton to small pelagic fish in the English Channel. We observed differences in zooplankton and phytoplankton communities, and in zooplankton and sardine FA composition between the western (WEC) and the eastern (EEC) basin, alongside variations in environmental conditions. Furthermore, fatty acid trophic markers and regression analysis revealed a trophic transfer of specific FAs. These findings indicated a strong bottom-up control from phytoplankton to small pelagic fish and revealed a spatial segregation of sardines corresponding to the WEC and EEC. Moreover, generalized additive models indicated an influence of the physiological status of sardines on the trophic transfer. In conclusion, this study highlights how the taxonomic composition and FA profile of phyto- and zooplankton can reveal spatial patterns in the nutritional potential for predators with potential consequences for subsequent trophic levels. Nonetheless, physiological factors in predators (e.g. Fulton's index) also influenced trophic transfer. We emphasize the usefulness of plankton taxonomic and chemical composition data for the investigation of marine food webs.

S09-17173 Oral CANCELLED

~~Highly productive, but not the same: Zooplankton traits driving trophic transfer efficiency in the Humboldt Current vs. the Benguela Current upwelling systems~~

~~Holger **Auel**, Maya Dalby, Sabrina Dorschner, Wilhelm Hagen and Anna Schukat~~

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~~Eastern boundary upwelling systems (EBUS) belong to the most productive marine ecosystems. They cover <2% of ocean surface, but provide 20% of global marine fisheries yields. Although similar in primary production, the Humboldt Current upwelling system (HCUS) supports five to eight times higher fisheries landings than other EBUS. Such extreme differences can only be explained by differences in the pelagic food-web structure and zooplankton trophic interactions leading to a much higher trophic transfer efficiency. Comparative studies in the HCUS and Benguela Current upwelling system (BCUS) show that the extreme oxygen minimum zone in the HCUS severely limits the vertical distribution of pelagic animals such as the dominant copepod *Calanus chilensis* and, hence, concentrates prey at the surface, providing efficient feeding conditions for the Peruvian anchovy *Engraulis ringens*. In contrast to its counterpart in the BCUS *Calanoides natalis*, *C. chilensis* does not conduct ontogenetic vertical migrations and follows completely different life-cycle strategies. The position of the HCUS closer to the equator results in upwelling effects reaching further offshore. While reproduction of *C. natalis* in the BCUS is limited to 50 to 70 km from the coast, *C. chilensis* reproduces up to >200 km offshore. Moreover, macrozooplankton, the krill *Euphausia mucronata* and the semi-pelagic squat lobster *Pleuroncodes monodon*, prevail in the HCUS. Together they can comprise >90% of "zooplankton" biomass. By partly feeding on benthic resources on the shelf and diel vertical migration, *P. monodon* opens a unique pathway of "reverse" carbon flux from the seafloor back into the pelagic food-web.~~

S09-17185 Oral (ECOP)

The diet of the bald notothen *Trematomus borchgrevinki*, a zooplanktivorous generalist, in East Antarctica

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Notothenioid fish are the dominant group of mesopredators in the high-Antarctic, commonly feeding on pelagic and ice-associated zooplankton. Obtaining information regarding their ecological role is key for understanding potential success or failure under changing Antarctic conditions. Diet analyses can reveal information about a species' functional placement in the food chain and direct observations of predation events and use of resources. The autecology of the notothenioid fish *Trematomus borchgrevinki* was studied in the Terre Adélie region of East Antarctica, near Dumont d'Urville station during summer. Stable isotopes ($d^{13}C$ and $d^{15}N$) and stomach contents were used to describe feeding ecology and foraging grounds throughout the summer season of mature specimens. The diet of *T. borchgrevinki* consisted mainly of the copepods *Paralabidocera antarctica*, *Stephos longipes*, and *Drescheriella glacialis*, all well-known ice-associated species, and the neritic krill *Euphausia crystallorophias*. Less common taxa included amphipods, chaetognaths, and larval fish, as well as some rarely observed pteropods, ostracods, and eggs. $d^{13}C$ and $d^{15}N$ signatures were characteristic of inshore secondary consumers. Stomach contents analysis showed that the fish were zooplanktivorous generalist feeders, primarily foraging at the sea ice interface and in the pelagic zone, and occasionally on the nearshore benthos. The plasticity we observed in diet and foraging indicates resilience to expected changing sea-ice conditions in the high-Antarctic.

S09-17208 Oral

Potential impact of zooplankton community composition changes on the fitness of *Sardina pilchardus* in the SW Mediterranean Sea

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Zooplankton are the main prey for small pelagic fishes of commercial interest, such as sardine and anchovy. These species and their larvae prey on the most abundant copepods in the SW Mediterranean Sea, but are also able to feed on other available preys, showing an opportunistic foraging behaviour. Changes in the zooplankton communities have been observed in the past decade (with increasing doliolids abundance in summer, and cladocerans in autumn); coinciding with the decline in small pelagic fish stocks in the region. Based on previous studies on the composition of European sardine (*Sardina pilchardus*) larval diet, we estimated the energy content (protein and lipid content) provided by their preferred prey (copepod nauplii), and compared it with the nutritional values that the current zooplankton community composition provides. We focused our study on the sardine reproductive season (autumn-winter) in order to elucidate the potential impact that climate driven changes in the sardine prey field could have on the condition and success of these species.

S09-17244 Oral (ECOP)

Larval Grey Rockcod: A potential climate change "winner" with implications for the western Antarctic Peninsula food web

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The western Antarctic Peninsula (WAP) was one of the fastest warming regions globally for most of the 20th century, leading to a long-term decrease in sea ice coverage. Many Antarctic fishes have specialized adaptations for surviving freezing waters and therefore, these unique fishes are expected to have low potential for adapting to warmer temperatures. However, species equipped with physiological and environmental plasticity may experience improved survival and expanded livable ranges, making them climate change "winners" in the Southern Ocean. We utilized a 27-year time series of length, abundance, and distributional data for larvae of the Notothenioid fish *Lepidonotothen squamifrons* (Grey Rockcod) to examine the potential of this species for adaptation and range expansion. Information on the early life stages of Grey Rockcod is scarce, however, physiological plasticity has been documented in adults. We show that since 1993, larval Grey Rockcod have shifted slightly poleward in mean latitude along the WAP while maintaining their northern distribution. Additionally, our model results indicate that larval abundance and growth rate increased at higher temperatures. These findings suggest that Grey Rockcod have the potential for range expansion along the WAP. An adult diet analysis shows that one of their most important food sources are gelatinous salps, which have similar ability to tolerate warmer and ice-free conditions. These are some of the first results to document a potentially favorable response of fishes endemic to the Southern Ocean to continued warming, which is important for understanding the future of this food web.

S09-17260 Oral (ECOP)

Eurytemora unmasked: The trophic role of a cryptic copepod complex in the St. Lawrence Estuary

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In the St. Lawrence Maximum Turbidity Zone (MTZ), a vital and productive nursery area, the dominant cryptic species complex of *Eurytemora affinis* serves as a critical link between primary production and higher trophic levels. Despite its importance as crucial prey for fish like rainbow smelt, little data exists on the specific contributions of the two sympatric cryptic species of this complex, *E. affinis* North-Atlantic clade (NA) and *E. carolleeae*. We aimed to analyze their tropho-dynamics and their contribution to the diet of larval smelt. Four surveys during the summer of 2021, covering a 100 km stretch of the St. Lawrence estuary from Quebec City to Anse Ste-Anne, revealed a heterogeneous distribution of rainbow smelt and their copepod prey throughout the habitat mosaic of the salinity gradient. *Eurytemora* showed high plasticity in its trophic position. Based on stable isotope analysis ($\delta 13C$ and $\delta 15N$) the trophic behavior varied between herbivory and carnivory depending on habitat and month. Furthermore, the energy transfer to larval smelt was characterized by the cryptic species complex emerging as the primary prey in June and July, accounting for 76% to 93% of the diet. Utilizing a novel SYBR green qPCR assay, we unveiled that the *E. affinis* NA predominated, comprising 72% of smelt stomach contents, while *E. carolleeae* played a minor role. *E. carrolleae* was consumed exclusively in low salinity habitats. This finding paralleled the dominance of *E. affinis* (NA) in the environment, suggesting that rainbow smelt larvae exploit and depend upon the most abundant resource available.

S09-17268 Oral (ECOP)

Trophic ecology of the little fish post-larvae of São Tomé Island

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Little fish are endemic species inhabiting the rivers of São Tomé and include at least three species: *Awaous lateristriga* (Duméril, 1861), *Sicydium brevifile* Ogilvie-Grant, 1884, *Sicydium bustamantei* Greeff, 1884. They are amphidromous fish, i.e., adults live upstream in rivers, the larvae hatch and migrate to the ocean with the river flow, where they will remain for a few months until they develop into post-larvae and migrate back to the rivers. Post-larvae migrations support important fisheries to local communities, that have been reporting its decline over the years. Thus, is urgent to increase knowledge about its biology and trophic ecology to achieve appropriate management and conservation measures. Preliminary previous results showed that *S. bustamantei* post-larvae are considered omnivorous and secondary consumers, while stable isotopes analysis indicated that zooplankton and macroalgae detritus were the main sources of organic matter assimilated by this species. The present study will compare the feeding ecology of little fish species on different locations of the island and different seasons using gut content and stable isotope analysis. Sampling occurred in May 2022 (wet season) and January and July 2023 (wet and dry seasons) in the north (Paga Fogo and Lembá) and the south coasts (Martim Mendes and Iô Grande). Several little fish post-larvae, potential carbon sources like plants, macroalgae, phytoplankton, zooplankton, and potential predators were sampled and will be analyzed to unveil its trophic ecology. Hopefully, this information will be helpful to develop management and conservation plans in the near future, supporting local communities to maintain this important economic activity.

S09-17301 Oral (ECOP)

Diel vertical migration, seasonality, and a long-term increase in larval deep-sea fishes in the subtropical North Atlantic Gyre

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Fishes frequently dominate animal biomass in mesopelagic ecosystems, and *Cyclothone*, a genus of bristlemouths (Gonostomatidae), is considered the most abundant vertebrate on the planet. The high global biomass, broad distributions, and diel vertical migration behavior of mesopelagic fishes suggest they are key mediators of deep-sea carbon storage. However, their patterns of abundance and sensitivity to environmental change remain poorly understood. We investigated diel, seasonal, and decadal patterns in the abundance of larval deep-sea fish taxa in the subtropical North Atlantic gyre from 1994-2021. Ichthyoplankton were incidentally collected in depth-stratified MOCNESS tows (0-700 m) and monthly day and night net tows in the epipelagic (0-200 m) through the Bermuda Atlantic Time-series Study. Larvae of mesopelagic fishes, including myctophids (lanternfishes) and *Cyclothone* (bristlemouths), were significantly more abundant in the epipelagic zone at night, which suggests they perform short-distance diel vertical migration as postflexion larvae and juveniles. Myctophids and *Cyclothone* dominated the ichthyoplankton assemblage during the spring and summer months. There was an increase in the springtime abundance of larval *Cyclothone* in the last decade of the 30-year time series. *Cyclothone* abundance was correlated with short- and long-term environmental variability, including total illumination, zooplankton biomass, mixed layer depth, and climate (e.g., Atlantic Multidecadal Oscillation). This is the first report of a long-term increase in the abundance of *Cyclothone* in an oligotrophic, subtropical gyre, the largest habitat on Earth. Our findings will help define the contributions of ichthyoplankton to carbon cycling and pelagic food web dynamics in open-ocean gyres.

S09-17363 Oral

Linking zooplankton to assessment and management of fisheries production in changing marine ecosystems

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While the importance of zooplankton in regulating fisheries production is well recognized, limited studies have been done to connect the dynamics of zooplankton and fish populations in fisheries stock assessment and management. A better linkage across the two fields can yield information critical to develop ecosystem-based fisheries assessment and management in the ever-changing oceans. However, a large knowledge gap exists currently regarding how, where and when to consider the dynamics of zooplankton that may influence the dynamics and production of fish populations, in particular recruitment dynamics and spatial/temporal distributions of fishes. In this talk we will review the status and approaches coupling zooplankton dynamics and fisheries populations, discuss conceptual and analytical bottlenecks as well as possible solutions to explicitly integrate zooplankton dynamics in fisheries stock assessment and management in the light of climate change.

S09-17392 Oral (ECOP)

Effects of climate-driven currents on copepods in the northeastern South China Sea

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It is of great significance to study the effects of climate-driven currents on the copepod size, abundance and biomass in the northeastern South China Sea for the utilization of fishery resources. In order to understand the spatial and seasonal pattern of the copepod community structure and their response to the changing environment, zooplankton was sampled during August 2015 and February 2016 (with intensified Kuroshio Intrusion). A total of 194 copepod species were identified. The species number of copepods is characterized by an increasing distribution from the continental shelf to sea basin and decreased with increasing depth. There was no significant difference in the copepod abundance between summer and winter, nevertheless the species number and biomass were significantly higher in summer than in winter. Copepod abundance was indirectly inhibited by the increasing intensity of Kuroshio intrusion in winter, but enhanced the species diversity in the slope and sea basin. With the increasing depth, the size spectrum of copepods shifted to the large-sized species with high biomass. Temperature, salinity and chlorophyll *a* were important environmental factors affecting copepods community. In addition, monsoon-driven currents have a direct effect on the vertical distribution of copepod, and indirectly regulate the spatial-temporal pattern of copepods by changing the hydrological environment. The dominant species *Calanus sinicus* is a reliable indicator of the Chinese Coastal Current in the northeastern monsoon, while the dominant species *Temora turbinata* is a good indicator of the coastal current in the southwestern monsoon, and *Heterorhabdus papilliger* is a good indicator of Kuroshio intrusion.

S09-17037 Poster

The diet of Anguilliformes leptocephali in the Kuroshio Current and adjacent waters

Gen **Kume**[1], Akinori Minagawa[2], Satoru Jinno[3], Junya Hirai[4], Kazuhiro Shiozaki[1], Mutsuo Ichinomiya[5], Tomohiro Komorita[5], Akimasa Habano[1], Masafumi Kodama[1] and Toru Kobari[1]

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Information on the feeding ecology of leptocephali is essential for the successful aquaculture of Anguilliformes fishes including Japanese eel *Anguilla japonica*. Generally, fish larvae mainly prey on mesozooplankton such as copepods. Meanwhile, previous studies have shown some evidence that leptocephali feed on particulate organic matters (POM). In the present study, we assessed the diet of early-development-staged leptocephali of dominant Anguilliformes fish in the Satsunan area, southern Japan through morphological and DNA metabarcoding analyses for gut contents and the stable carbon and nitrogen isotope analysis. The purpose is to elucidate which components of POM leptocephali feed on. Samples were collected by an Ocean Research Institute net (diameter: 160cm; mesh size: 335μm) from 2015 to 2022. A total of 284 leptocephali (18 taxonomic group) were used for the present study. A wide variety of eukaryotes (16 taxonomic groups) were detected by DNA metabarcoding analysis for gut contents, supporting the previous implication that leptocephali feed on POM. By electron microscopic observations, zooplankton fecal pellets and amorphous particles that would be components of zooplankton fecal pellets were dominantly observed in their guts. The stable isotope analysis indicated that fecal pellets of calanoid copepods would be a main source of nutrition for leptocephali. In the many regions, copepods are main components of zooplankton. Our study strongly suggests that leptocephali would feed on POM such as fecal pellets of copepods occurring abundantly in the ambient environment, which can pass through the space between fang-like teeth.

S09-17079 Poster

Comparison of abundance and composition of fish larvae community in autumn and spring in the waters surrounding the Taiwan Bank, western North Pacific

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Temporal variation of fish larvae community related to the hydrographic characteristics in the waters surrounding the Taiwan Bank was studied in October 2021 (autumn) and March 2022 (spring). A total of 149 taxa of fish larvae belonging to 96 genera and 71 families were identified during the study period. *Engraulis japonicas*, *Diaphus* slender type, unidentified Gobiidae, *Apogon* sp., unidentified Clupeidae, and *Benthosema pterotum* were the six most dominant taxa, together constituted 47.39% of the total catch. No significant temporal difference in abundance of fish larvae was found, but the species number of fish larvae was more diverse in spring than in autumn. The species composition showed significant difference between cruises, and a clear temporal structure for the assemblage of fish larvae was revealed by the cluster analysis. The intrusions of monsoon-driven currents (China Coastal Current, South China Sea Warm Current, and Kuroshio Branch Current) transported various fish larvae to this study area. The distributional pattern of fish larvae was closely related to the hydrographic characteristics, with seawater temperature, salinity, and zooplankton abundance being the significant explanatory variables affecting the assemblage structure of fish larvae in the waters surrounding the Taiwan Bank.

S09-17153 Poster

Interannual variability in zooplankton biomass and relationships with the early marine survivals of Pacific salmon in the Salish Sea, BC, Canada

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Zooplankton are a vital link between lower (i.e. phytoplankton) and upper (i.e. fish) trophic levels. In the Strait of Georgia (northern Salish Sea, BC, Canada), zooplankton have been routinely monitored on a monthly basis for the past 10 years. Salmon populations in the Strait have experienced huge changes in their abundance, including large reductions in returns and high variability in year to year abundances. The Salish Sea Marine Survival Program was a Canada – U.S. collaborative multi-year research initiative established to investigate two main questions: what has driven the very strong declines in abundances of Coho and Chinook populations in the Salish Sea since the 1980s; and what determines the interannual variability of present populations. In this study we examined the role zooplankton biomass and community structure had on the variability of key salmon species of this region. We identify interannual trends of total zooplankton biomass and its major constituents, including those taxa identified as comprising important dietary items for Coho and Chinook. We show variations in these zooplankton groups over time are important variables in the modeled early marine survivals of some Chinook and Coho Salmon populations that enter the Strait as juveniles, and provide predictive relationships.

S09-17336 Poster (ECOP)

Distribution and Abundance of Chaetognaths in Verde Island Passage, Southern Luzon, Philippines during the summer with emphasis on Flaccisagitta *enflata* (Grassi, 1881) and *Aidanosagitta neglecta* (Aida, 1897*).*

Graziele Ann S. **Taclas**[1], Wilfredo L. Campos[1,2]

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Verde Island Passage (VIP) is a crucial, biodiverse marine corridor, with unique hydrographical features and processes driving high primary productivity that supports rich fisheries for small pelagic fish. Zooplankton links such high productivity and the higher trophic levels, which are important to fisheries production. Chaetognaths are important predators of zooplankton, including fish eggs and larvae. They are sensitive to environmental changes and serve as biological indicators associated to specific water masses and productive areas. While a few studies on chaetognaths relative to water movement have been conducted in the country, their spatial distribution and abundance in VIP is unkown. Thus, this study aims to address this gap. Zooplankton samples and physico-chemical parameters were collected during an oceanographic survey conducted in May 2007 in VIP. Vertical hauls were made using a Working Party 2 (WP-2) plankton net with 200 µm mesh size. Samples from 24 stations were sorted into major plankton groups, while chaetognaths were identified to species level. Generally, haetognaths were more concentrated at bay entrances and the narrow Marikaban Strait. The most abundant species *Flaccisagitta enflata*, followed closely by *Aidanosagitta neglecta*, were found in all 24 stations. Mapped relative percentage distribution showed *F. enflata* was highest at the opening of Balayan Bay and Tayabas Bay, while *A. neglecta* was densest at Batangas Bay. This is affirmed by cluster analysis, with *F. enflata* denser within the strait and, *A. neglecta* denser at the periphery. Differences in chaetognath abundance and distribution relative to the spatial distribution of environmental factors are discussed.

Session 10: Zooplankton in changing polar oceans

Convenors:
Guang Yang (China), corresponding
Hauke Flores (Germany)
Kohei Matsuno (Japan)

Invited Speakers:
Geraint A. Tarling (British Antarctic Survey, UK)

Zooplankton, mainly krill and copepods, play great roles in polar ocean ecosystems. They serve as trophic links that transfer carbon and energy from microalgae to higher trophic levels. Meanwhile, they also contribute in determining the efficiency of the biological carbon pump of polar oceans via passive sinking of moults, carcasses, feacal pellets and via activities such as grazing, diel vertical migration and respiration. The polar ocean is undergoing rapid climate change (e.g. warming, changes in extent of sea ice) with contrasting rates and directions among different sectors of Arctic Ocean and Southern Ocean. These changes have had and would have profound impacts on the distribution, phenology, community of zooplankton and their role played in structure, function and service of polar ocean ecosystems. In this session we welcome submissions on all polar zooplankton related topics, including but not limited to comparison of key species or functional groups and the maintenance of biodiversity and ecological processes (e.g. trophodynamics, biogeochemical cycle) in the regional and circumpolar scale of both Arctic Ocean and Southern Ocean, examining the short-term or time-series response and resilience of zooplankton to climate and environmental change using traditional and new methods, discussing new monitoring technology (mooring, molecular approaches) which can be used in future polar zooplankton research. We encourage bipolar comparisons of zooplankton communities with respect to e.g., ecosystem functions and services, biodiversity, vulnerability/resilience to change.

S10-17247 Invited

Calanus finmarchicus in a region of rapid change: from expatriation to life-cycle completion at its Arctic range-edge

Geraint A. **Tarling**[1], Jennifer J. Freer[1], Neil S. Banas[2], Mayleen Blackwell[3], Claudia Castellani[4], Kathryn B. Cook[5], Malin Daase[6], Magnus L. Johnson[4], Kim S. Last[7], Penelope K. Lindeque[4], Daniel J. Mayor[5], Elaine Mitchell[7], Helen E. Parry[4], Douglas C. Speirs[2], Gabriele Stowasser[1], Marianne Wootton[8]

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Biological communities in the Arctic are changing through the climate-driven encroachment of subarctic species, termed borealisation. *C. finmarchicus* is a biomass dominant species in the North Atlantic that is known to be expatriated to the Arctic but not able to complete its life-cycle there and recruit locally. As part of the DIAPOD programme, we examined the biology and distribution of *C. finmarchicus* at its habitat range edge through reanalysis of historical records combined with two multidisciplinary sampling research cruises. We divided historical data into two eras, 1955–1984 and 1985–2017, and used an optimized MaxEnt model to predict the seasonal distribution of the abiotic niche. We found large and significant increases in habitat suitability in the regions of the Greenland, Labrador, and Southern Barents Seas. Most of these areas also show a seasonal shift in the timing of peak habitat suitability toward an earlier season. For the field campaigns, we targeted Fram Strait, one of the regions predicted to have increased habitat suitability. We found the *C. finmarchicus* population there to be capable of amassing enough energy (lipid) reserves to overwinter. Early developmental stages were also present in early summer, suggesting successful local recruitment. This extension to suitable *C. finmarchicus* habitat is most likely facilitated by the long-term retreat of the ice-edge, allowing an earlier and longer phytoplankton bloom and with higher temperatures increasing copepod developmental rates. The increased capacity for this species to complete its life-cycle at Arctic range-edges can change community structure, with large consequences to regional food-webs.

S10-17043 Oral

Comparison between zooplankton production and polar cod distribution in the Pacific Arctic Ocean during October 2020: combination approach of plankton net and environmental DNA

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In association with drastic sea-ice reduction, environmental condition and plankton distribution are changing in the Pacific Arctic Ocean. These changes could impact ecology and distribution of polar cod (*Boreogadus saida*), which is an important fish species in the Arctic marine ecosystem. However, the relation between zooplankton and the fish is not fully understood in this region. Therefore, we investigated the zooplankton community and polar cod distribution in the Pacific Arctic Ocean during October 2020 with combined use of plankton net sampling and fish environmental DNA (eDNA) detection. A cluster analysis based on species composition and abundance clearly indicated that zooplankton community was divided into shelf and slope groups. A distance-based linear modeling exhibited that temperature and time since sea-ice melt were significant drivers of the change for zooplankton community. Subsequently, production of zooplankton was estimated for each taxon based on their body size/weight and ambient temperature. In terms of the production, the shelf community was dominated by small copepod *Pseudocalanus* spp. and *Oithona* spp., while the slope community was dominated by Chaetognatha and large copepod such as *Calanus glacialis/marshallae* and *Metridia longa*. A pairwise correlation analysis indicated that concentration of polar cod eDNA positively correlated with the abundance of distinct species depend on regions; *Acartia* spp. and *Microcalanus* spp. in the shelf, while *Oncaea* spp., copepod nauplii, *C. glacialis/marshallae* and *Pseudocalanus* spp. in the slope. This regional difference is potentially due to species-specific distribution in zooplankton and implied the heterogeneity in prey availability for polar cod in the Pacific Arctic.

S10-17050 Oral (ECOP)

Macrozooplankton from Crozet to Kerguelen and subtropical Southern Indian Ocean

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Plankton plays an important role in the functioning of Antarctic ecosystems. Plankton is an important prey item for several species of top predators and provides a link between phytoplankton and the top of the food chain. It is therefore important to be able to identify species assemblages associated with particular areas in order to predict their evolution and their impact on the ecosystem. The aim of this study was to describe the diversity and biogeography of macrozooplankton according to oceanographic zones between the South Indian Ocean and the North Indian sector of the Southern Ocean. Correspondence analysis and biogeographic network method on abundance data obtained by species identification during the REPCCOAI programme campaigns revealed a strong biogeographic separation in the sub-Antarctic zone. A separation between the Antarctic zone and the polar frontal zone highlights the role of the subantarctic islands in the biogeography of the southern plankton, while differences in assemblages in the southern Indian Ocean seem to indicate an influence of the Agulhas Return Current.

S10-17062 Oral (ECOP)

Maximum entropy (MaxEnt) model predicts northward shift in Bering Sea cold pool and change in euphausiid distribution

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The Southeastern Bering Sea supports a biodiverse community with commercially important fish and internationally protected species that consume euphausiids for energy. Its community structure relies on the southward movement, formation, and breakup of seasonal sea ice to regulate cold water circulation and nutrient fluxes: both are fundamental aspects of metabolic rate and productivity. The Bering Sea's cold pool extent varies seasonally and annually, triggering large shifts in available nutrients, plankton diversity, and the northward migrations of commercially valuable fish. Here we document 1980-2018 monthly shifts in cold pool extent, fragmentation, and motion to quantify its influence on southeastern Bering Sea krill relative occurrence rate. Using bottom water temperatures and a space-state model to identify multidecadal periods of high/low cold pool extent, over 20,000 SEBS krill samples, and corresponding time-specific environmental covariates (primary production, salinity, pH, currents, wind), we employ a maximum entropy (MaxEnt) model to predict krill relative occurrence rate and driving variables for each of the major warm and cold regimes. The model suggests a recent northwestward shift of the cold pool centroid and simultaneous shrinkage in average annual extent. In years with a reduced cold pool extent, euphausiid presence may shift northward consistent with cold water temperatures and high nutrient availability. As a dominant mid-trophic zooplankton group, euphausiid distribution serves as a crucial indicator for both phytoplankton prey and predatory marine mammals, sea birds, and fish. The results of this study document the cold pool's changing regimes while exploring how and why they may impact Bering Sea euphausiids.

S10-17074 Oral (ECOP)

Using acoustic data to evaluate critical zooplankton prey thresholds for foraging bowhead whales in the Canadian Arctic

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Bowhead whales (*Balaena mysticetus*) are an iconic Arctic species with a critical ecological role and cultural importance to Inuit communities. They reach up to 80 tonnes and 18-20m, yet feed on zooplankton which are orders of magnitude smaller than them. Zooplankton abundance and distribution are changing rapidly in the warming Arctic, and this may have direct impacts on bowheads. To forecast the timing and scale of impact, data on the threshold prey density for successful bowhead feeding are required. However, zooplankton densities can be extremely patchy over a range of temporal and spatial scales, strongly influenced by oceanographic conditions which alter the location of energetically profitable prey patches. We report data on the distribution of zooplankton around feeding bowhead whales obtained from an echosounding, netting-, and oceanographic survey in Iqalujjuaq Fjord, Cumberland Sound, Nunavut in August 2023. These data were collected through a systematic survey of the entire fjord in addition to opportunistic sampling near feeding whales.

Calanoid copepods make up the majority of zooplankton biomass available to foraging bowhead whales. Due to Arctic warming, large, lipid-rich high-Arctic species such as *Calanus hyperboreus* and *C. glacialis* may be increasingly replaced by smaller, more boreal species such as *C. finmarchicus*. We conducted the acoustic surveys at two frequencies (120 kHz and 200 kHz) in the hope of distinguishing between zooplankton size classes. This, together with zooplankton net samples, should enable us to infer the species composition of the bowhead diet and move toward the capability to predict impact of change.

S10-17078 Oral (ECOP)

Deciphering food web architecture under various dynamics of sea ice in the East Antarctic

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Sea ice in East Antarctica has tended to increase in terms of extent and decrease in terms of days of coverage. Marine food webs are strongly influenced by sea ice dynamics which is characterised by marked spatio-temporal variations. To understand the ecological implications, we depicted the architecture of the zooplanktonic (including Euphausiids) food web structure in the East Antarctic off Mawson station. We used integrative trophic biomarkers (stable isotopes: $\delta^{13}C$ and $\delta^{15}N$) to explore trophic interactions of key zooplankton taxa (Euphausiids, pteropods, salps, copepods and amphipods) to sea ice. Cluster analysis (maximum likelihood based on isotopic composition) divided our data set into areas proximate and far from the sea ice. The SIBER package (in R&Rstudio) was used to estimate the two communities' convex hull area and niche width. Preliminary results showed different trophic architecture in the two areas. Firstly, in terms of the food web length, we found increased carnivory as the sympagic reliance increased. Secondly, fewer trophic links were found in areas closer to the sea ice. Niche overlap and width were also evaluated for all taxa and grouped geographically (proximate and far from sea ice), evidencing more competition near the sea ice edge. Other trophic metric and GLMs to evaluate the relationship with sea ice are in progress. Thus far, the results provide insights into how Antarctic grazers might adapt their feeding habits in response to environmental conditions and trophic resource availability changes. They also show that local sea ice trends in Antarctica can potentially cause changes in food web structure.

S10-17081 Oral (ECOP)

Zooplankton vertical stratification in the East-pacific and Indian sectors of the Southern Ocean

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The vertical structure, including abundance and community composition, of zooplankton and associated environmental drivers in Antarctic waters is not well understood, particularly in the mesopelagic and upper bathypelagic layers. Depth-stratified zooplankton samples were collected from 0 to 1500 m during four summers in the East-Pacific and Indian sectors of the Southern Ocean. In addition, multivariable analysis of environmental drivers including temperature, salinity, oxygen, and chlorophyll *a* concentration, as well as water masses was conducted. Based on cluster analysis, nine different zooplankton communities were identified across the two sectors. These communities generally corresponded to either the epipelagic layer or the deeper layers, respectively. In both sectors, the epipelagic layer was dominated by cyclopoid copepods, such as *Oithona similis* and *Oncaea curvata*, as well as calanoid copepods including *Calanoides acutus*, *Rhincalanus gigas*, and *Ctenocalanus citer*, while copepods and other taxa including chaetognaths, amphipods, and ostracods, were important contributors to the deep layer communities. Moreover, zooplankton abundance decreased with depth in both sectors, while diversity was highest either in the epipelagic or mesopelagic layer. Our multivariable analysis has revealed that the physical characteristics of water masses, including specific temperature and salinity ranges, the Southern Boundary of the Antarctic Circumpolar Current, Southern Antarctic Circumpolar Current Front, and depth, are important drivers for structuring zooplankton communities. In addition, the vertical distribution patterns of zooplankton align with the biotic properties of different water masses or layers, such as food availability. Furthermore, both sectors display a similar composition of zooplankton, with dominance by copepods and krill, outnumbering salps. This finding suggests the existence of two similar planktonic food webs in the East-Pacific and Indian sectors of the Antarctic Zone.

S10-17094 Oral

Zooplankton community and transport dynamics in the Bering Canyon and Unimak Pass regions of the Bering Sea, Alaska

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Transport of zooplankton onto the shallow Bering Sea shelf from the deeper, off-shelf basin has been shown to be an important process that provides prey for fish, birds and marine mammals. Basin copepod species tend to be larger and more lipid rich than those originating from the continental shelf, and available evidence suggests basin-origin taxa form an essential part of the prey base. Oceanographic exchange between the basin and the shelf is facilitated through submarine canyons along the Bering Sea slope, providing an advective conduit for zooplankton. Located in the southeast Bering Sea shelf-break, Bering Canyon is thought to be one such conduit; however, seasonal and spatial dynamics of the zooplankton community are not well understood. Whole water column plankton sampling occurred across transects spanning Bering Canyon and the Unimak Pass region in the spring and fall of 2014 and spring of 2015 to better describe zooplankton species composition, distribution, seasonal patterns and transport. Cluster analyses were used to describe how plankton assemblages differed in spring and fall, by year and how they may be influenced by water mass patterns. Key copepod species (*Neocalanus* spp. and *Calanus marshallae / glacialis*.) were investigated further, as they are important prey for juvenile Walleye Pollock (*Gadus chalcogrammus*) entering their first winter. Results show distinct spring and fall zooplankton communities as well as spatial patterns indicating the influence of several flow patterns in the region, which help resolve mechanisms of transport through Bering Canyon and demonstrate basin-shelf connectivity.

S10-17143 Oral (ECOP)

Physiological condition and distribution of *Calanus hyperboreus* and *C. glacialis* highlight interspecies differences in their life cycle strategy within the central Arctic Ocean

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The calanoid copepods *Calanus hyperboreus* (CH) and *C. glacialis* (CG) dominate the zooplankton biomass in the Arctic Ocean, but the absence of early life stages has raised questions whether they represent expatriates advected from adjacent regions. We examined the distribution, stage composition, dry weight and individual lipid content, as well as egg production, of these species across two transects in the central Arctic Ocean during fall 2011. Although reproductive activity and early developmental stages were observed only on the fringes of the deep basins, the abundances of late copepodites and adult females remained at consistent levels across the study area for CG and increased away from the shelves for CH. We found no decline in lipid content or dry weight in adult CG away from productive regions and only a slight drop in adult CH. Lipid content and dry weight in C5 copepodites, on the other hand, dropped significantly with distance to the shelf break, with the decline most pronounced in CH. This suggests that although early life stages of *Calanus* spp. are incapable of developing in the food-limited conditions of the deep Arctic basins, the adults of both species can self-sustain there for seemingly indefinite periods. This unique ability may allow them to be eventually transported to more favourable regions. We propose that their success in the central Arctic is due to the combination of advection from the outer shelf together with their ability to survive for protracted periods as adults in the deep basin under severe food limitation.

~~S10-17177 Oral (ECOP)~~ CANCELLED

~~Euphausiids Unveiled: Comprehensive Study of *E. superba*, *E. crystallorophias* and *E. triacantha Diet* – a DNA metabarcoding and Stable isotope approach.~~

~~Camila **Cataldo-Mendez**[1,2], Kerrie Swadling[1,2], Alison Cleary[4], Leonie Suter[3], Christine Weldrick[1,2]~~

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~~Krill species play an important role in the East Antarctic ecosystem and have historically been studied predominantly for their economic importance, with Antarctic krill (*Euphausia superba*) given the most attention regarding their dietary preferences. However, this study expands our understanding by including two lesser-studied krill species: crystal krill (*Euphausia crystallorophias*) and tri-spined krill (*Euphausia triacantha*).~~

~~Species were collected in overlapping distributions/stations, offering the opportunity to investigate whether different krill species either compete for resources or exhibit distinct dietary preferences when coexisting in the same geographical area. This study uses a combination of methods to examine the diets of Antarctic euphausiids. DNA metabarcoding analysis, performed on stomach samples, provides a snapshot of their diet at the time of capture, while stable isotope analysis on muscle tissue sheds light on the origin of resources used for growth. Additionally, this approach yields valuable trophic information, including trophic position, niche width, and the extent of dietary overlap among species.~~

~~Notably, this research marks the first investigation of *E. superba* specimens captured on the seafloor, representing a significant milestone in the field. Preliminary findings indicate that when *E. superba* and *E. crystallorophias* overlap in their habitats, they have a dietary shift, evidentiate by changes in trophic position. This study enhances our comprehension of the complex interplay between krill species and their interactions within the East Antarctic ecosystem, offering critical insights into their ecological roles and resource utilization.~~

S10-17189 Oral

Impact of sea-ice decline on Arctic zooplankton vertical migration revealed by an autonomous observatory and implications for ecosystem monitoring in the polar oceans

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As sea ice deteriorates, more light enters the polar oceans, causing largely unknown effects on the ecosystem. A novel autonomous bio-physical observatory provided the first record of zooplankton vertical distribution under sea ice drifting across the Arctic Ocean from dusk to dawn of the polar night. Its measurements revealed that zooplankton ascend into the under-ice layer during autumn twilight, following a consistent trigger isolume. We applied this trigger isolume to IPCC models enabled to incorporate incoming radiation after sunset and before sunrise of the polar night. The models project that, in about three decades, the total time spent by zooplankton in the under-ice layer will be reduced by up to one month, depending on geographic region. This will impact zooplankton winter survival, the Arctic foodweb, carbon- and nutrient fluxes. These findings highlight the importance of processes in the twilight periods for predicting change in high-latitude ecosystems. In this presentation we will discuss implications of changing light regimes for zooplankton winter survival in both polar oceans and possible impacts on ecosystem functioning, and the potential of autonomous observatories for monitoring zooplankton and fish in ice-covered waters.

S10-17239 Oral (ECOP)

Bipolar sex ratio study reveals a decade of reproductive abnormalities in Arctic ostracods

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Present in both the Arctic and Antarctic, ostracods are still a widely understudied zooplankton group. Their features are sexually dimorphic, but with a lack of taxonomic experts and seven life stages (A-6, A-5, …A-1, and Adult) in pelagic species, polar ostracods are challenging to identify. Here, a robust dataset of historical and contemporary data was compiled to explore variation in ostracod sex ratio with respect to species, depth, region, season, and ontogeny. Global ostracod populations in the Arctic and Antarctic demonstrated a stable female bias of ~60-70% over all tested factors. However, this female bias was even higher when only the pre-mature A-1 stage was considered, reaching a striking female proportion of almost 1.0. This sex ratio at the A-1 life stage is inconsistent with the Adult sex ratio, pushing us to find the cause of this overwhelming female bias. During micro-dissections of decadal (2009-2020) samples from the Arctic, morphological abnormalities were found in A-1 ostracods that imitated the reproductive organ of males (i.e., pseudopenises) but otherwise appearing as typical females. These reproductive abnormalities can only be seen when micro-dissected, so in historical sex data, A-1 ostracods with pseudopenises may have been assigned females without resolving if they could be genotypically male. These abnormalities have not been observed in samples from earlier years, suggesting that such shifts could result from environmental changes. It is crucial to monitor this phenomenon because it could generate problems with zooplankton identification and lead to consequences in interpreting ecological trends in the polar regions.

S10-17243 Oral (ECOP)

What we do in the dark: Prevalence of omnivorous feeding activity in Arctic zooplankton during polar night

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During the productive polar day, zooplankton and sea-ice amphipods fulfill a critical role in energy transfer from primary producers to higher trophic-level species in Arctic marine ecosystems. Recent polar night (i.e., winter) studies on zooplankton and sea-ice amphipods suggest higher levels of biological activity than previously assumed. However, it is unknown if these invertebrates maintain polar night activity on stored lipids, opportunistic feeding, or a combination of both. To assess how zooplankton (copepods, amphipods, and krill) and sea-ice amphipods support themselves on seasonally varying resources, we studied their lipid classes, fatty acid compositions, and compound-specific stable isotopes of trophic biomarker fatty acids during polar day (June/July) and polar night (January). Lipid storage and fatty acid results confirm previously described dietary sources in all species during polar day. We found evidence of polar night feeding in all species, including shifts from herbivory to omnivory. Sympagic-, pelagic-, and *Calanus* spp.-derived carbon sources supported zooplankton and sea-ice amphipods in both seasons. We provide a first indication of polar night feeding of sea-ice amphipods in the pelagic realm.

S10-17262 Oral

Unique zooplankton diversity in the deep Nansen and Amundsen basins of the Arctic Ocean.

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The Eurasian part of the central Arctic Ocean consists of two deep basins separated by the Gakkel Ridge: the Nansen Basin and the Amundsen Basin. The Nansen Basin is influenced by the inflow of warm and nutrient-rich Atlantic Water. On the contrary, the Amundsen Basin is influenced by the Transpolar Drift and Siberian River inflow. With these contrasts in environmental conditions and potential consequences on the primary production, the two basins likely have different zooplankton compositions. Global warming with rising ocean temperatures and reduced sea-ice cover will potentially change the condition for the zooplankton community and might increase the survival of advected boreal species in the area. Our study provides an inventory of the current status of the zooplankton composition in the two Arctic Ocean Eurasian Basins based on samples from September 2021 and August 2022. Zooplankton was sampled with stratified vertical net hauls using two separate MultiNet Midi (opening: 0.25 m^2, 5 nets), one with 64 µm and one with 180 µm mesh nets to cover the entire size range of the mesozooplankton community. Selected stations were also sampled with Multinet Mammoth (HydroBios, opening: 1m^2, 9 nets), to obtain a finer mesozooplankton depth resolution down to 4244 m depth. This is one of the first studies comparing the mesozooplankton communities in these two contrasting basins with extra emphasis on the deeper basin communities. We also compare the zooplankton communities in the two basins between two years with different ice conditions.

S10-17324 Oral (ECOP)

Meroplankton distribution hotspots along the Northeast Atlantic shelves

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Meroplankton, which comprises of larval stages of benthic invertebrates that seasonally supply the zooplankton community, is sensitive to every disturbance in their environment, including physico-chemical conditions (e.g., variation in temperature, salinity) and biological conditions (e.g., shifts in food availability). Shelf areas are places where environmental conditions change dynamically under the influence of local factors and current inflows of different water masses. Our research area covers Northeast Atlantic shelves, where warm Atlantic waters, rapidly intrude towards the north, contributing to the Atlantification of the Arctic, and where they meet the cold Arctic waters of the Sørkapp current forming the polar front. Sample collection was carried out in summer 2021 and 2022; at each station, zooplankton was taken by vertical hauls from the bottom to surface using Juday plankton net (mesh size 56µm) and at once was preserved in 95% ethyl alcohol. Meroplankton was analyzed morphologically under a stereomicroscope, and different morphotypes of larvae were assigned. Additionally, the impact of environmental conditions on the meroplankton community was examined. Here, we describe the spatial variability of meroplankton along the transect from the West Coast of Norway to West Spitsbergen, with a special emphasize on hotspots of larval diversity. Preliminary results show interesting hotspots of Holothuroidea cf. larvae around the Bear Island (Bjørnøya) and Phoronidae and specific Asteroidea cf. larvae on the southeastern coast of Norway. Moreover, Echinodermata ophiopluteus larvae seem the most resistant to different environmental conditions and occurred nearly throughout the research area.

S10-17329 Oral (ECOP)

Detecting zooplankton foray behaviour in a polar oceanic environment

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Foray behaviour involves vertical movements between the surface and deeper layers by individual zooplankton. Unlike diel vertical migration, where there is a synchronised movement between deeper and shallower layers at restricted times in the diel cycle, foray behaviour describes unsynchronised movements that occur over a much broader daily time window. Traditional sampling techniques, such as nets and active acoustics, have difficulty in detecting this behaviour as it does not involve a vertical shift in biomass but rather an exchange of individuals of which some will be moving upwards as others are moving downwards. Detecting the behaviour is important as it may be an unquantified contributor to the active flux of carbon to the ocean interior. We developed the Motion-compensated Upward and Downward Looking (MUDL) net to detect foray behaviour in open-ocean environments. The device is a motion-compensated ship-tethered trap into which zooplankton swim into upward or downward looking nets (through upward or downward forays) over a discrete time period. The MUDL net was deployed at a number of stations across the Polar Frontal Zone (northern Scotia Sea, Southern Ocean) during the austral summer of 2016-2017. Our results revealed that a large number of polar zooplankton species undertake forays. Of particular note was the large contribution of the copepod *Oithona* spp. to catches of both the upward and downward looking nets. Our study demonstrates the utility of our MUDL net for quantifying the extent of foray behaviour in the open ocean, and parameterising its contribution to active carbon flux.

S10-17337 Oral

Year-round reproductive activity of copepods in the Arctic Ocean

Barbara **Niehoff**[1], Johanna Bürger[1], Astrid Cornils[1], Nadine Knüppel[1], Carin Ashjian[2], Robert Campbell[3], Giulia Castellani[1], Hauke Flores[1], Celia Gelfman[3], Nicole Hildebrandt[1], Serdar Sakinan[4], Katrin Schmidt[5], Katyann Shoemaker[3] and MOSAiC TEAMs ECO & OCEAN

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Reproductive traits are crucial to the life history strategy of a species. The reproductive biology of Arctic copepods, especially the large *Calanus* species, has been previously studied. However, data from winter and early spring are rare and knowledge is still limited on small species that may remain active year-round. To fill this gap, we collected zooplankton near weekly from November 2019 to September 2020 during the MOSAiC expedition with *R/V Polarstern*, following the transpolar drift in the Arctic Ocean. Most copepods are transparent and therefore female gonad maturation can be followed based on morphological changes of the oocytes visible in the prosoma. Immature oocytes are small and transparent while advanced and mature oocytes are large and brownish, the latter being indicative of reproductive activity. Depending on abundance, we sorted all or at least 50 females of each taxon from each sample and identified females with immature or advanced/mature oocytes. Here, we will present the reproductive cycles of the most abundant species, including understudied taxa such as *Microcalanus, Spinocalanus* and *Scaphocalanus*, and discuss their potential role in energy fluxes in Arctic ecosystems, especially in deep water layers

S10-17341 Oral (ECOP)

From polar night to midnight sun: exploring functional diversity of copepod communities in the Barents Sea

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Copepods dominate the zooplankton community in terms of species richness and numbers in sub-Arctic and Arctic seas. They are very successful in these strong seasonal environments and to assess the different expressions of functions performed by the copepods we are using a trait-based approach.

The aim is to gain insights into the composition and distribution of functional traits within the species pool and unravel relationships among functional traits, the environment, and the community structure. We hypothesise that copepod communities will be differently shaped during different times of the year and therefore bear different associated functions. Data were gathered within the framework of the Nansen Legacy in the Barents Sea, encompassing the eastern Svalbard region, over four distinct campaigns, notably including the sparsely studied winter season.

To achieve the results we employed ordination methods, exploring the interconnection among traits, environment, and abundances. Furthermore, different functional diversity indices were investigated to capture the seasonal variation, elucidating how the seasons impact the ecological contributions of copepods and their ecosystem role. Finally, RLQ (co-inertia analysis) was carried out to gain an integrated view.

Our preliminary results show that despite strong seasonal variations, the pooled copepod community assembly is rather resilient with little seasonal variability.

In conclusion, by exploring the intricate relationships between copepods, their functional traits, and the environment, we are seeking a deeper understanding of the vital role copepods play in the face of seasonal variability in the Arctic.

S10-17405 Oral

The combined influence of the Labrador Current and the West Greenland Current on the zooplankton community structure in the Northern Labrador Sea

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The zooplankton of northern Labrador has been barely described despite its crucial role in food web and biogeochemical processes in an oceanographically complex area connecting the Arctic and Western North Atlantic. Under climate warming, this region is undergoing rapid environmental change, affecting the functioning of the marine ecosystem. We sampled mesozooplankton from 2006 to 2020 at 48 stations in four northern Labrador fjords (Nachvak, Saglek, Okak, Anaktalak), and offshore on the western Labrador continental shelf and slope. A multivariate analysis revealed two main assemblages, which grouped, respectively, the coastal stations of the fjords (coastal assemblage) and the offshore stations across the outer continental shelf and slope (offshore assemblage). The neritic copepod *Pseudocalanus* spp. dominated the coastal assemblage, followed by the ubiquitous *Oithona similis,* also abundant at offshore stations. However, the offshore assemblage was characterized by the Atlantic oceanic copepods *Calanus finmarchicus, Oithona atlantica,* and *Microcalanus* spp. Offshore, the large biomass of copepods (>4 g C m^{-2}) was due to the relatively high abundance of the large oceanic *C. finmarchicus* and *C. hyperboreus*. Transport of *C. hyperboreus* in some of the fjords and the contribution of the large arctic *C. glacialis* yielded relatively high biomass in some of the fjords also. The drivers of zooplankton community structure in the northwestern part of the Labrador Sea will be discussed, especially the interplay between the cold Labrador Current flowing southward from the Arctic along the Labrador Coast and a westward flowing branch of the Atlantic-influenced West Greenland Current.

The dual influence of the Labrador Current and the West Greenland Current on the zooplankton community structure

S10-17049 Poster (ECOP)

Zooplankton abundance, distribution and size structure along the Mawson coast, East Antarctica

Christine K. **Weldrick**[1], Inessa Corney[1,2], Madeleine J. Brasier[1,2], Alicia Burns[1,3,4], Olivia J. Johnson[1,2], Jessica Melvin[1,2,5], and Dale Maschette[1,2,5]

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The horizontal community structure of zooplankton along East Antarctica (55°E to 80°E) was determined from RMT1 plankton net samples collected as part of the TEMPO survey program during the summer of 2021. From this community structure, species abundances and distribution were estimated, and a suite of environmental covariates were analysed to determine any drivers of zooplankton communities. Hierarchical agglomerative clustering revealed three groups of zooplankton broadly separated based on environmental characteristics. Abundance was highest for cluster 1 (74,386 ind. 1000 m^{-3}), which was dominated by small copepods. The highest number of stations ($N = 34$) are represented by this cluster, spanning the greatest N-S and E-W distances, the deepest waters (mean = 3,475 m) and relatively highest concentrations of integrated chlorophyll-*a* (mean = 49.13 mg m^{-2}). The smallest number of sites form cluster 2 ($N = 4$), which is comprised the lowest abundance (1,059 ind. 1000 m^{-3}). A moderate abundance (22,629 ind. 1000 m^{-3}) was estimated at cluster 3, which was located closest to the continental shelf. Generalized additive modeling indicates that chlorophyll-*a* and temperature were highly significant ($p < 0.001$) predictors of abundances of indicator zooplankton species. To a lesser degree but still significant ($p < 0.01$) were number of days since sea ice melt and mixed layer depth. Our findings provide valuable insights into the impacts of climate change on key zooplankton communities, shedding light on the flow-on effects throughout the Antarctic ecosystem.

S10-17093 Poster (ECOP)

What shells can tell us: Seasonal changes in calcification depth of Southern Ocean pteropods

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Thecosome (shelled) pteropods, a group of pelagic molluscs, are at risk from ocean acidification, with known effects on their shell durability and calcification. Their shells are composed of a more soluble form of calcium carbonate, known as aragonite which typically dissolves when the aragonite saturation state (Ω_{Ar}) of seawater is less than 1; this circumstance is referred to as the aragonite undersaturation state. Shelled pteropods typically form their aragonite shells at specific depth ranges known as the 'calcification depth', which varies depending on species and habitats. Some regions of the Southern Ocean are already experiencing brief periods of wintertime aragonite undersaturation from the surface down to 100 m depth which could potentially negatively affect shelled pteropods, however their calcification depths have never been investigated nor subsequently used to indicate consequences of changing seawater carbonate chemistry in the Southern Ocean. There is urgency to study the calcification depths of shelled pteropods and investigate whether they change these depths to avoid the aragonite undersaturation state of seawater. This study aims to address this gap by using stable oxygen isotopes analyses to reveal an estimate of the calcification depth and any seasonal trends in the area where aragonite undersaturation occurs. The anticipated outcome is the development of a standardised methodology to study the effects of ocean acidification using the calcification depth of shelled pteropods as an indicator.

S10-17213 Poster

Arctic zooplankton in changing marine lightscape

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The Arctic marine lightscape is changing. As a part of global warming, changes in the sea ice, snow cover, melt ponds and river runoffs have been detected. Retreating sea ice is likely to increase human presence in the Arctic Ocean, exposing the environment to more human induced light pollution. All these factors bring unforeseen changes into marine light conditions. Light-guided activities are central phenomena in the marine ecosystem. Organisms have evolved under predictable light regimes resulting in biological rhythms synchronized with light cues which may be altered with the changing lightscape. The photobiology of Arctic zooplankton is still full of mysteries, but the latest technical developments provide new tools to address some of the key questions. We have applied a multi-tool approach to understand the impacts of the natural light regime (intensity, spectral composition and photoperiod) and changing lightscape on Arctic zooplankton. By complementing traditional plankton net tows and acoustics with eDNA metabarcoding, we have achieved a taxonomically more comprehensive picture of the effect of light on the spatial distribution of zooplankton. With behavioral experiments and studies on visual physiology by microspectrophotometry and electron microscopy we have revealed differences in visual functions at the species and population levels. Our results indicate that Arctic zooplankton species have separate visual niches and their response to a changing lightscape may therefore differ. We suggest that a species-specific functional light regime should be considered when predicting the effects of environmental changes on Arctic zooplankton.

S10-17219 Poster

Overwintering in the Central Arctic: Vertical and seasonal distribution of mesozooplankton

Astrid **Cornils**[1], Barbara Niehoff[1], Nicole Hildebrandt[1], Nadine Knüppel[1], Carin Ashjian[2], Robert Campbell[3], Giulia Castellani[1], Celia Gelfman[3], Serdar Sakinan[4], Katrin Schmidt[5], Fokje Schaafsmaa[4], Katyann Shoemaker[3], Martina Vortkamp[1], Hauke Flores[1] and MOSAiC TEAMs ECO & OCEAN

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Sea ice coverage and thickness are declining in the Central Arctic Ocean (CAO), causing changes in light, temperature, and primary production by both phytoplankton and ice algae and, consequently, substantial changes in mesozoplankton community structure and vertical distribution. The international MOSAiC (Multidisciplinary drifting Observatory for the Study of Arctic Climate) expedition provided a platform to study the zooplankton in the CAO in the water column over an annual cycle using a variety of nets. We conducted horizontal net tows below the ice (0 and 10m depth) and vertical depth-stratified net tows in five depth strata (0-50-200-500-1000-2000m) at approximately weekly intervals. Samples were digitized with the ZooScan/ZooProcess, yielding images that were sorting semi-automatically into taxonomic categories using the web application EcoTaxa. With the resulting data, we will assess how the environmental factors (e.g. light, temperature, salinity, chlorophyll *a*, sea-ice cover) are associated with changes in seasonal and vertical mesozooplankton distribution patterns. We will especially focus on the scarcely studied winter months. Finally, we will compare our results to previous summer expedtions to the Central Arctic Ocean.

S10-17254 Poster

Ecophysiology of *Calanus finmarchicus* in the Fram Strait during and after the phytoplankton bloom

Kathryn B. **Cook** [1,9], Florence Atherden [1,2], Holly Jenkins [1,2], Elaine Mitchell [3], Barry Thornton [4], Penelope K. Lindeque [5], Helen E. Parry [5], Elodie Jacob [1,7,8], Geraint A. Tarling [6], Daniel J. Mayor [1,9]

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The copepod *Calanus finmarchicus* is a dominant component of pelagic food webs in the northern North Atlantic. Warming sea temperatures are allowing *C. finmarchicus* to expand their range northwards, and they are becoming increasingly important in the Arctic Ocean with potential consequences for ecosystem productivity. Our objective was to examine how key physiological rates in *C. finmarchicus* relate to environmental and biological conditions, with a focus on animal biomass (in terms of C and N). In field expeditions to the Fram Strait during May 2018 and August 2019, we measured (1) respiration, using Electron Transfer System (ETS) enzyme activity as a proxy, (2) biomass, both of *C. finmarchicus* females and pre-adult copepodite stages (CV), (3) egg production rate (EPR) and (4) egg hatching success (HS). CVs had higher C:N ratios than females, indicating higher lipid content, whilst females had higher C:N ratios in May compared to August. Biomass-specific respiration rates were lower in CVs than in females, and lower in animals caught at depth compared to the surface. C:N ratio was the most significant predictor of temperature-corrected respiration rates. The most important predictors of EPR were the percentage of spawning females (%SF), which in turn was highly correlated with temperature and spring chlorophyll, and C:N ratio of females. Temperature, %SF and C:N ratio of females were also significant predictors of HS. These results highlight the importance of accounting for C and N contents of animals when incorporating important lipid-storing zooplankton species in biogeochemical models.

S10-17307 Poster

Assimilation and turnover rates of specific lipid compounds in dominant Antarctic copepods: CSIA, a cutting-edge tool to reveal ecophysiological adaptations in polar oceans during times of climate change

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The study revealed species- and stage-specific differences in lipid accumulation of dominant Antarctic copepods, the primarily herbivorous *Calanoides acutus* (copepodids CV, females) and the more omnivorous *Calanus propinquus* (females), storing wax esters and triacylglycerols, respectively. Feeding carbon-labelled diatoms to these copepods, ^{13}C signatures elucidated assimilation and turnover rates of total lipids as well as specific fatty acids and alcohols. The ^{13}C incorporation was monitored by compound-specific stable isotope analysis (CSIA). Copepodite stage CV of *C. acutus* exhibited an intense total lipid turnover and 55% of total lipids were labelled after nine days of feeding. In contrast, total lipid assimilation of female *C. acutus* and *C. propinquus* was clearly lower with 29% and 32%, respectively. The major dietary fatty acids 16:0, 16:1(n-7) and 20:5(n-3) showed high turnover rates in all specimens. In *C. acutus* CV copepodids, the high rates of the *de novo* synthesized long-chain monounsaturated fatty acids and alcohols 20:1(n-9) and 22:1(n-11) indicate intense lipid deposition, whereas these rates were low in the females. These high-resolution data of lipid assimilation and turnover provide a much better understanding of lipid metabolic pathways. Lipid accumulation of zooplankton key species, especially herbivores, is a crucial process in polar oceans buffering the extreme seasonality of primary production. These life history traits are well synchronized with seasonal events. However, environmental change at high latitudes may decouple e.g. light- and temperature-controlled processes and thus result in a mismatch situation of primary and secondary production impacting lipid biosynthesis of herbivores.

S10-17344 Poster

The role of zooplankton in carbon and nitrogen transformations in the Central Arctic Ocean

Robert G. **Campbell**[1], Carin Ashjian[2], Cecilia Gelfman[1], Katyanne Shoemaker[3], Giulia Castellani[4], Nicole Hildebrandt[4], Serdar Sakinan[5], Katrin Schmidt[6], Astrid Cornils[4], Sandra Murawski[4], Barbara Niehoff[4], Hauke Flores[4] and MOSAiC Team ECO

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Transformations and fluxes of carbon (C) and nitrogen (N) between atmosphere, ice, and ocean are mediated by physical and biological processes and take place at the ocean-ice-boundary. Conditions in the near-surface ocean are influenced also by ecological characteristics from deeper in the water column, in the upper mixed layer, in the euphotic zone, or, for zooplankton, over the depth habitat of key species. Understanding of C and N ocean-ice-atmosphere fluxes requires a broad focus on lower trophic level processes near the ice and in the underlying water column and the linkages between the two systems. Transformations of C and N by the lower planktonic trophic levels in the upper water-column and near the sea ice-ocean boundary were studied over an annual cycle during the course of the MOSAiC (Multidisciplinary drifting Observatory for the Study of Arctic Climate) expedition. Zooplankton rate processes for key species, including respiration, feeding, reproduction and growth, were quantified in terms of C and N, and their seasonal cycles fully described. This study is novel in that it is the first quantification of the planktonic food web dynamics in the central Arctic through direct measurement of the important biological rate processes over an annual cycle.

S10-17414 Poster (ECOP)

Physiological tolerance of Southern Ocean zooplankton

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The physiological limits of marine crustaceans are determined by the physical characteristics, such as temperature, of the environment they inhabit. In the Southern Ocean, crustaceans are subjected to low and relatively constant temperatures and our knowledge of their resilience to warming is limited. Previous research has indicated that the thermal response of zooplankton may be species-specific. For example, pteropods exhibit increased metabolic rates making them potentially vulnerable to temperature stress, whereas modelling of krill suggests increases in biomass per recruit, making them resilient to a future Southern Ocean. In general, there is uncertainty around how many groups of Southern Ocean zooplankton will respond, including copepods and the larval stages of euphausiids. In this study, we investigate the thermal tolerance of furcilia and juvenile Antarctic krill (supplied by the Australian Antarctic Division) by conducting temperature ramp experiments. We measured the respiration rates of these two life stages to determine their response to step-wise increases in temperature. We collate our findings with published literature to help shape our understanding of the future of Southern Ocean zooplankton.

Session 11: Advancements in zooplankton censusing and monitoring technologies

Convenors:
Kim Davies (Canada), corresponding
Anais Lacoursiere (Canada)

Invited Speakers:
Joseph Warren (Stony Brook University, NY, USA)

Novel zooplankton sampling techniques are beginning to increase space-time coverage by zooplankton population censuses, causing a shift in research attention toward collecting and processing zooplankton "big data". Use of autonomous platforms, remote sensing, bioinformatics and computer science is proliferating to both improve estimates of zooplankton population sizes and assess morphological traits more rapidly and at larger spatio-temporal scale. Key areas of research development include performance testing, validation, and use case studies and implementation of monitoring programs. This session invites presentations on the applications of new technology and techniques that advance our ability to measure the distribution, abundance and taxonomic composition of free swimming zooplankton in the ocean. Presentations are invited on use of autonomous ocean vehicles, acoustics, eDNA, satellites, imaging, machine learning, big data, bioinformatics or any other related topic. Comparative studies that address the pros and cons of different technologies are encouraged. The scope of presentations should address how these approaches are advancing our ability to census free-swimming zooplankton in situ.

S11-17251 Invited

Trading space for time: What are the opportunities (and challenges) when we replace (or combine) vessel-based zooplankton sampling with long-duration, fixed-location measurements?

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For a variety of factors, vessel-based projects studying zooplankton are being combined with (or replaced in part by) autonomous platforms or new methodologies. While some areas of zooplankton research will always require net-collection of physical specimens, there are many aspects of zooplankton ecology where studies taking advantage of these new approaches can offer novel insights. Vessel-based surveys using scientific echosounders and other methods typically sample large areas of the ocean over days to weeks with only seasonal or annual (or in many cases, no) replicate measurements at specific locations. Autonomous vehicles (either surface or submerged) can expand that coverage in space and time, but are still limited in their endurance. Instrumented moorings provide a completely different set of observations which can cover a wide range of time scales (seconds to years) but at a fixed location in the ocean. So how can these two approaches be best combined? What do we gain (and lose) when we shift resources from boats with people to instruments operating independently? Three case studies will be presented: concurrent observations of epi and mesopelagic zooplankton and nekton aggregations off the NW Atlantic continental shelf from vessels and upward-looking bottom-mounted echosounders; seasonal patterns in zooplankton abundance in the Gulf of Maine from fixed upward-looking, multi-frequency echosounders with very limited vessel sampling; and the integration of fixed echosounder monitoring as part of a New York state-funded, long-term, large-area monitoring study of the NW Atlantic continental shelf.

S11-17052 Oral (ECOP)

Developing a high-throughput genetic method to elucidate the diversity and abundance of zooplankton from Southern-Ocean Continuous Plankton Recorder (CPR) collections

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Zooplankton play essential roles in food webs and biogeochemical cycling in the Southern Ocean. Given the expected impacts of climate change, a greater understanding of community dynamics is critical to anticipate shifts and establish ecosystem monitoring and conservation. Continuous Plankton Recorders (CPRs) are deployed from vessels to enable wide-ranging, long-term, and cost-effective zooplankton collection. However, sample processing has traditionally relied upon morphological identification, which requires significant time and expertise, frequently resulting in under-analysis of samples. CPR-collected specimens are also often damaged, hindering identification. Genetic techniques can improve the speed and accuracy of analysis, streamlined by processing all specimens consistently. Primers targeting areas of high DNA sequence variability across taxa are also essential. To address inconsistent sequence data availability across Southern-Ocean species, we developed a universal DNA extraction protocol then tested multiple primer sets targeting the COI gene and full, ~3300-bp 18S operon. The extraction and amplification protocols were optimized to function across 9 phyla, covering 65+ taxa. Using bongo specimens identified by a taxonomic expert, we built a reference sequence database via Sanger and Nanopore sequencing. These sequences will populate a publicly available, Southern-Ocean-specific database and be used to further fine-tune the identification process. Presently, sequences from 50+ taxa have been collected for universal Southern Ocean primer set development. Our goal is to develop a high-throughput, sequencing-independent genetic CPR pipeline; thus, the process from CPR deployment through sample analysis is undergoing optimization. Upon completion, this genetic method should have broad utility, applicable across sampling methodologies and throughout the Southern Ocean.

S11-17181 Oral

Integrating modern techniques with traditional plankton taxonomy

Felicity R. **McEnnulty**[1], Anthony J. Richardson[2,3,4], Claire H. Davies[1], Frank E. Coman[2], Ruth S. Eriksen[1], Jason D. Everett[2,3,4], Anita Slotwinski[2], Mark L. Tonks[2] and Julian Uribe-Palomino[2]

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Traditional taxonomic identification to species level requires specialist skills, is time consuming and expensive since zooplankton are represented across many phyla. Technological advances and novel methods of data acquisition and interpretation can be used in a complementary manner with traditional methods. For the past 15 years CSIRO Australia has monitored the plankton from the Integrated Marine Observing System National Reference Stations and underway samples from the Continuous Plankton Recorder using traditional microscopy. This data is shared to the Australian Ocean Data Network where it is available for download and analysis. Advances in data visualization led to the development of the IMOS Biological Ocean Observer, an interactive web page making our data accessible and interoperable to a range of users from skilled analysts to the general public.

In recent years, we have explored new options for quality control between taxonomists in cataloging digital imagery including databases in the cloud and developing online factsheets and interactive keys. We have used imaging systems and analysis platforms such as Zooscan, Ecotaxa (zooplankton) and Flowcam (microzooplankton and larger phytoplankton) to develop size-based data products. A human element requiring specialist taxonomic knowledge is required to validate the processed results of these technologies. Micro CT scanning has been trialed to create 3D digital models of zooplankton. To accommodate the rapidly expanding demands of eDNA analysis we have investigated genetics techniques and providing verified material to global databases. The use of bioacoustics to estimate zooplankton biomass from echosounders is also ongoing research that requires validation through taxonomic knowledge.

S11-17236 Oral

A comparative analysis of DNA metabarcoding and morphological identification for evaluating zooplankton diversity in the Pearl River Estuary, China

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Zooplankton plays a pivotal role in material circulation and energy flow in marine ecosystems. To evaluate zooplankton diversity in the Pearl River Estuary, we examined the zooplankton community structure across a salinity gradient using morphological analysis and DNA metabarcoding with the 18S rDNA and COI marker genes. We collected these samples directly from the water or filtered them through various mesh sizes. A total of 191 Operational Taxonomic Units (OTUs) belonging to invertebrates were identified using 18S rDNA with 152 species annotated. Among them, 38 OTUs of zooplankton were recorded with 27 species annotated. A total of 670 invertebrate OTUs were identified based on the COI marker gene with 565 species annotated, including 92 OTUs of zooplankton and 76 species annotated. At the phylum level, the number of invertebrate identifications obtained from 18S rDNA and the COI gene was comparable. Excluding planktonic larvae, we identified a total of 52 zooplankton species through morphological analysis. Among zooplankton, only Penilia avirostris was identified using all three methods, with the COI gene revealing a greater diversity of zooplankton species. The analysis outcomes of the samples were also influenced by the mesh size used. Our findings indicate that DNA metabarcoding yields complementary estimates, rather than identical ones, when compared to traditional zooplankton assessment methods. Nevertheless, if it undergoes widespread validation and refinement, this method could offer a valuable alternative for studying zooplankton ecology. In the future, DNA metabarcoding holds promise for large-scale studies and assessments of zooplankton diversity.

S11-17281 RecordedOral

Pop Goes the Plankton: Investigating the soundscape of copepods using active and passive acoustics

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Sound is a mechanism used by many marine animals to communicate, navigate, and survive. However, the soundscapes of invertebrates are generally understudied. A recent study of the sounds produced by the copepod *Calanus finmarchicus* revealed “cracking-click” sounds (Kühn et al., 2023), however, the precise characteristics of these sounds, probable production mechanism, their function and role in the environment, remain unknown. To further understand and describe these sounds, our study used rarely combined active and passive acoustic techniques (acoustic doppler current velocimeters (ADCPs) and hydrophones respectively) and video. Our approach was to: (i) make audio-visual lab recordings of captive *C. finmarchicus* obtained from a sea loch off western Scotland, and (ii) combine active and passive acoustic data from a mooring in Kongsfjorden, Svalbard, Norway, where *C. finmarchicus* are part of the zooplankton community. These approaches provided a detailed analysis of an individual species and overall zooplankton soundscapes. Laboratory results captured distinct acoustic signals of individuals and groups of *C. finmarchicus* on video, suggesting that the sound is produced during swimming, or ‘hopping’. Analysis of the mooring data showed a positive relationship between zooplankton biomass/vertical velocity as detected by the active acoustics, and the ambient sound as detected by passive acoustics. These findings show that species-specific acoustic signatures, which contribute to the zooplankton soundscape, potentially provide another method for understanding daily vertical migration and predator-prey interactions. The potential of anthropogenic sound pollution to disrupt low amplitude invertebrate noises is furthermore highlighted and discussed in the context of our findings.

S11-17291 Oral

The implementation of a mesozooplankton automated classification system to optimize the Canadian bivalve Aquaculture Monitoring Program

Anaïs **Lacoursière-Roussel**[1], Thomas Guyondet[1], Chris McKindsey[1], Stephen Finnis[1], Ruben Cordero[1], Ramon Filgueira[2], Cyril Aubry[3] and Frédéric Maps[3]

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We have been mandated to develop a national Aquaculture Monitoring Program (AMP) to evaluate if there are food web interactions via zooplankton depletion in bivalve aquaculture sites as predicted by theoretical models and experiments. Imaging instruments can potentially revolutionize the approach to monitor changes in mesozooplankton composition rapidly and consistently over time using automated classification systems. For instance, these technologies can process a greater number of samples in reduced time relative to traditional microscopy and enabling highly accurate morphological measurements required for modeling the impacts of farmed bivalve grazing on energy transfer to higher trophic levels. With the goal of implementing these technologies nationwide and reduce bias in management decisions, we will show how we are assessing the reliability of imaging technologies for mesozooplankton across a diverse array of coastal ecosystems. First, we evaluate mesozooplankton size distributions across various bivalve aquaculture embayments in Atlantic and Pacific Canadian coastal regions. Second, we compare mesozooplankton community structure from the first nationwide study within Canada using imaging systems and contrast the efficiency of imaging (FlowCam) and eDNA metabarcoding data. Finally, we contrast taxa-specific abundance estimates between imaging systems and traditional microscopy and show the efficiency of automated classification systems (Ecotaxa) among coastal ecosystems: low diversity, high diversity, and highly-dominated ecosystems. Conclusions will provide direct advice on optimal workflows to monitor long-term changes in mesozooplankton communities in coastal temperate embayment using imaging systems.

S11-17349 Oral

Evaluating new approaches for zooplankton monitoring and ecology studies: is eDNA a tool that is ready to advance our science?

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Multiple long-term time series in the Northern California Current use traditional plankton net based sampling and morphological taxonomy to monitor seasonal and interannual fluctuations in the biomass and distribution of plankton communities.
Complimenting traditional methods with eDNA could provide new opportunities for sampling zooplankton and add insights into their ecology. To evaluate this new approach, raw CO1 reads from 65 samples collected from a broadscale survey (41.6˚N – 48˚N) in September 2020 were clustered into 6455 ASVs using dada2. Taxonomic assignment of ASVs was attempted using multiple approaches: RESCRIPt, NCBI blastn with BASTA, QIIME2 VSEARCH (MetaZooGene barcode atlas as reference), and SINTAX (pretrained CO1 model). Using these approaches only 272-700 ASVs were assigned to species, including phytoplankton, zooplankton, and fish. The species classifications of the most commonly classified zooplankton ASVs were generally consistent with morphological species identifications. Difficulties encountered include lack of (1) standardized workflow and common reference database, and (2) confidence that taxonomic classification of ASVs was as complete as possible, despite technical limitations. Choice of classification scheme and reference taxonomic database can significantly alter the types of analyses and conclusions researchers can make. To alleviate gaps in reference libraries, more specimens are needed to provide CO1 sequences from known organisms. A standardized database including all known CO1 barcodes with curated and up-to-date taxonomic data will improve use of eDNA for integrative hypothesis testing. Along with discussion of limitations, we will present results that address the utility of integrating eDNA analysis into these monitoring programs.

S11-17398 Oral

Performance of profiling glider-mounted echosounders at detecting deep layers of large copepods

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Profiling electric gliders are mobile, battery-powered autonomous vehicles that can carry a variety of oceanographic sensors. Our research program has been experimenting with several different sensor technologies to better understand their performance at measuring the abundance and distribution of large, lipid-rich *Calanus* spp. copepods. This talk focusses on the performance of one sensor, the Acoustic Zooplankton Fish Profiler (AZFP; ASL Ltd), a 4-frequency unit that can be deployed on a glider to sample continuously for ~2 months at a time on typical lithium battery missions. Two performance studies are discussed. The first saw the glider-mounted AZFP deployed alongside conventional shipboard samplers to intercompare vertical abundance and distribution data. We found that the AZFP was able to detect the presence and absence of *Calanus* layers in the 455 kHz frequency band, and resolve patchiness within the layers, but the absolute abundances were underestimated by a factor of 2-3 compared to shipboard samplers. The second study saw the glider deployed along transect lines in a multi-month mission to quantify the spatial distribution of near-seafloor *Calanus* layers. Very preliminary results indicate that the AZFP was able to detect near bottom layers and the high sampling frequency will allow kriging to measure the sectional distribution of *Calanus* across oceanographic and bathymetric gradients.

S11-17462 Oral CANCELLED

~~Temporal variations in acoustic backscatter from zooplankton and small pelagic fish aggregations.~~

~~Downie R.A.[1], Macaulay G.J.[2], Ben~~ **~~Scoulding~~**

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~~Zooplankton communities are a critical component of marine ecosystems, responsible for the transfer of energy between primary producers and consumers to higher trophic levels that are of ecological and economic importance. Recent work has indicated that bioacoustic sensors may be able to quantify the seasonal and interannual variation in key zooplankton functional groups required for ecosystem model initialisation and assessment. We will demonstrate how a timeseries of multifrequency (38, 125, 200 and 455 kHz) acoustic backscatter data from a seafloor lander can deliver regional estimates of zooplankton abundance of value to ecological models. Estimates of organism size and numerical abundance were derived using the Species Identification Methods From Acoustic Multi-frequency Information (SIMFAMI) plankton inversion algorithm implemented in the LSSS acoustic processing software. The inversion algorithm used a set of backscattering models to represent different organism scattering types and a minimisation procedure to find the best fit between the observed multifrequency backscatter and the scattering models. The scattering models used in this analysis were fluid bent cylinder, gaseous sphere, hard shelled sphere and fluid spheroid Distorted Wave Born Approximation (DWBA). These categories cover small organisms with and without a gas bubble (e.g., a swimbladder), crustaceans, copepod~~, and jellyfish.

Session 13: Dynamics and role of diapausing copepods in marine ecosystems

Convenors:
Jeffrey Runge (USA), corresponding
Johanna Aarflot (Norway)
Carin Ashjian (USA)
Rubao Ji (USA)

Invited Speakers:
Malin Daase (UiT The Arctic University of Norway)
Ann Tarrant (Woods Hole Oceanographic Institution (WHOI), USA)

Diapausing calanoid copepods (especially in the genus Calanus and Neocalanus) are supremely adapted to the seasonality of polar and subpolar ocean habitats. They play a key role in the functioning of marine ecosystems, including biogeochemical cycling and trophic dynamics. Lipid storage is necessary for survival of diapausing copepods and also supports higher trophic levels in higher-latitude food webs. This session invites contributions from modeling, observational and experimental studies about this functional group. Subjects may include but are not limited to: 1) trends in abundance and body size, 2) how environmental factors influence population dynamics, 3) the role of predation in determining copepod dynamics, distribution, phenology and life history, 4) developmental, physiological and genetic mechanisms underlying the diapause and life history strategies; 5) patterns and consequences of phenological variability and biogeographic boundary shifts, 6) theoretical, statistical and dynamic modeling analyses and future projections of diapausing copepod abundance and 7) impact of change in abundance of diapausing copepods on higher trophic levels.

S13-17166 Invited

Activity patterns and respiration rates of overwintering Arctic and subarctic Calanus species

Malin **Daase**[1,2], Estelle Coguiec[1], Kim Last[3], Jonathan Cohen[4], Gérald Darnis[5,6] and Maxime Geoffroy[6]

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Copepods of the genus *Calanus* are key species in Arctic and subarctic marine ecosystems. Once they have stored enough energy reserves during the productive season, they perform seasonal vertical migration to greater depth to overwinter in a state of diapause. Recent observations from the European Arctic have shown that overwintering *Calanus* terminated diapause already in January, long before the onset of the spring bloom, and suffered high mortality, possibly caused by insufficient lipid stores to sustain metabolism during the food-scarce winter. We still have a poor understanding of *Calanus* activity levels during the extensive overwintering period and if all copepods reach actual diapause. Under global warming, winter temperatures are increasing, thereby affecting metabolic cost during overwintering. How these environmental changes will affect the winter survival of *Calanus* populations is still uncertain.

Using modified Trikenetics locomotor activity monitors, we have measured activity patterns of overwintering stages of *Calanus* species from the Norwegian and Canadian Arctic. Combined with measurements of respiration rates and lipid content, we will discuss how this approach can provide new insights into overwintering strategies of different populations and species. Using this approach, we studied the effect of temperature on activity patterns and respiration rates of overwintering stages of the boreal-Atlantic *Calanus finmarchicus* along its pathway from the Norwegian Sea to the Arctic Ocean at the start and towards the end of the overwintering period. Responses varied among the different populations, reflecting local adaptation and the degree to which this *Calanus* expatriate into the Arctic is affected by advection.

S13-17427 Invited

Heterogeneity in physiological condition of diapausing copepods

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In temperate and polar oceans, a group of calanoid copepods have developed a highly successful life history strategy that includes grazing on ephemeral phytoplankton blooms, accumulating large amounts of lipid in a specialized storage organ, and surviving unfavorable periods in a dormant state called diapause. The ability of copepods to complete their lifecycle and successfully reproduce varies in space and time and will continue to vary in response to environmental changes in ways that are currently difficult to predict. Scientists have increasingly leveraged a set of morphological, physiological, and molecular measurements to gain insight into the conditions that copepods have previously experienced and their adaptive and acclimatory responses. This presentation will examine the ways in which integrative approaches have enabled the development of informative molecular biomarkers, as well as the ways in which molecular studies have provided new insights into the physiological ecology of diapausing copepods. I will discuss observed physiological variation within copepod populations and the need to couple such studies with autonomous sensing, ecological monitoring programs, and population modeling efforts.

S13-17025 Oral

Fat chance: can in situ imagery and machine learning provide a clearer picture of Arctic zooplankton lipidscape ?

Frédéric **Maps**[1,2], Piotr Pasza Storożenko[3], Jędrzej Świeżewski[3], Cyril Aubry[1,2], Sakina-Dorothée Ayata[4]

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Plankton imaging systems supported by automated classification and analysis have improved ecologists' ability to observe aquatic ecosystems. Today, we are on the cusp of reliably tracking plankton populations with a suite of lab-based and in situ tools, collecting imaging data at unprecedentedly fine spatial and temporal scales. But these data streams have potential well beyond examining the abundances of different taxa; the individual images themselves contain a wealth of information on functional traits. Here we outline the potency of this approach by a case study of Arctic copepods that dominate the zooplankton assemblages in these ecosystems, in part because of their large lipid content. Lipid is the staple of trophic networks and copepods tend to store them in large lipid sacs than can occupy up to 80% of their body volume. We trained a U-net algorithm to high-resolution in situ images of these organisms to provide accurate estimates of individual lipid content, opening for the first time a window on interindividual variability in lipid content, as well as global estimates that could reveal the organization and inner functioning of lipid-based Arctic marine ecosystem processes. Finally, the approache we discuss is data agnostic and is broadly applicable to most aquatic organisms and ecosystems.

S13-17051 Oral (ECOP)

Winter recruitment of lipid-rich copepod nauplii in the Northern Gulf of Alaska

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The Northern Gulf of Alaska (NGA) experienced a major marine heatwave from 2014-2016 that impacted multiple trophic levels. It resulted in high mortality of marine mammals and seabirds as well as low recruitment of commercially important fishes. These declines have been attributed, in part, to changes in the zooplankton community and decreased lipid-rich copepod abundances. Moreover, analysis of historic spring zooplankton collections revealed a shift in dominance among the lipid-rich copepods from *Neocalanus flemingeri* to *Calanus marshallae* in the coastal NGA. While both species serve similar ecosystem functions, they differ in reproductive strategy and timing, which could result in the delayed recruitment of lipid-rich nauplii—an important prey source for winter-spawned larval fish. Yet, copepod nauplii remain poorly studied due to identification challenges and limited winter sampling. To evaluate species-specific naupliar recruitment, biweekly sampling was conducted in Resurrection Bay, Alaska from January through March with zooplankton collected from three depth strata between the surface and 300 meters. Size-fractioned community DNA metabarcoding and species-specific polymerase chain reaction assays were used to identify and estimate relative abundances of nauplii with quantitative emphasis on *Neocalanus* and *Calanus*. Ovigerous female *Neocalanus flemingeri* and nauplii were present from the start of the sample period and developed throughout the season. Conversely, ovigerous female *Calanus marshallae* and nauplii were not present until the end of March corresponding with an increase in chlorophyll. Thus, a lasting shift towards a *Calanus marshallae*-dominated community could result in a mismatch of naupliar prey with winter-spawned first-feeding larval fish.

S13-17107 Oral

Spatio-temporal Dynamics of *Calanus finmarchicus* on the Northwest Atlantic Shelf

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Calanus finmarchicus, a lipid-rich calanoid copepod, plays a pivotal role in the pelagic food web of the North Atlantic Ocean. Despite its essential role, a comprehensive understanding of its variability patterns and interconnections with environmental drivers remains incomplete. This study integrates decades-long regional plankton datasets, multi-year cruise observations, and novel statistical methods to elucidate the complex population dynamics in the Northwest Atlantic Shelf - Gulf of Maine region. Our results suggest that interannual variability in the Gulf of Maine is largely influenced by internal population dynamics, with a pronounced sensitivity to top-down influences. Seasonal studies highlighted the significant role of local predation in shaping diapausing populations. Moreover, spatial synchrony analyses on the Northwest Atlantic Shelf suggested that, although interconnected by advection, *C. finmarchicus* subpopulations are not always in synchrony, emphasizing the key role of local habitat heterogeneity. In summary, while broader regional factors do exert influence, local population dynamics are instrumental in shaping *C. finmarchicus* variability.

S13-17118 Oral

The search for a molecular signature for dormancy in calanoid copepods

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Diapause, a type of dormancy is a strategy shared by many *Calanus* and *Neocalanus* congeners. With global warming, marine habitats are changing both in surface and deep waters, raising questions about how these environmental trends might affect diapausing copepods. However, investigating the role of diapause in marine ecosystems requires the identification of diapausing populations and determining their physiological state. Thus, it is important to distinguish non-diapausing from diapausing individuals, including those that might be either preparing or emerging from the dormant state. A multi-trait phenotype, diapause involves the reduction of metabolic rates, arrest of development, increase of longevity and protection against cellular stress. Using the sub-Arctic copepod *N. flemingeri* as a model organism, we used transcriptional profiling of adult females and nauplii to characterize the profiles of dormant and non-dormant individuals. We identified a “diapause toolkit” composed of a set of 30 genes. The expression profile of these genes typified the dormant state across multiple years (2015-2021), and across developmental stages.

S13-17172 Oral

Mechanistic Modelling of Seasonal Vertical Migrations in a Changing Climate

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The marine biological carbon pump is a key component of the global carbon cycle, significantly regulates Earth's past and present climate, and provides the main source of energy for organisms living in the mesopelagic and deep ocean. Changes in the organic carbon transport to the deep sea may have significant consequences for the future climate, for fisheries and ecosystem services, and may be related to past atmospheric CO2 concentration changes. Yet, our current understanding of the biological pump is incomplete and simplistic, and consequently its response to anthropogenic stressors, in particular climate change, remains highly uncertain.

We present a novel global mechanistic phenomenological model of copepod diapause and which is implemented within the coupled carbon cycle & climate Earth system model GFDL–ESM2M. The model accurately captures known global diapause patterns and observed local migration behaviours. In this paper, we provide an estimate to the global contribution of diapause to deep (lipid) carbon export. Finally, we detail the sensitivity of the future carbon cycle and atmospheric CO2 to these changes in diapause, and explore climatic feedbacks in a series of climate projections.

S13-17227 Oral

The southern Gulf of St. Lawrence as foraging habitat for the North Atlantic right whale: the role of *Calanus* diapause and regional circulation

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Calanus copepod species are dominant members of North Atlantic continental shelf zooplankton communities and important prey for planktivores including the endangered North Atlantic right whale (NARW). Diapause timing and vertical distribution strongly influence shelf supply and 3-D spatial distribution. Here, we assess the influence of diapause on *Calanus* supply and aggregation in the southern Gulf of St. Lawrence (sGSL), a shallow shelf and persistent NARW foraging habitat since the mid-2010s. Following *Calanus* depletion in the sGSL during fall-winter, the area is resupplied through transport from the Laurentian Channel, mainly via the Gaspé Current, when *Calanus* emerge from diapause and return to near-surface waters. *Calanus hyperboreus* are transported into the sGSL during their active period (ca. March-June), while immigration of *C. finmarchicus* extends from ca. March through the summer months. The magnitude and distribution of resupply depends on upstream concentrations and circulation patterns during the *Calanus* spp. active periods. Dense near-bottom layers mainly of *C. hyperboreus,* with energy levels exceeding the minimum threshold for profitable NARW foraging, are formed as early as mid-May in the sGSL through interaction of vertical movement and shallow bathymetry, and dense mixed-species layers are observed locally in the sGSL in summer. The density of near-bottom prey layers can be dynamic at short time scales, possibly due to weak local retention. This study provides a case study of how diapause influences distribution and dynamics of *Calanus* spp. in shelf waters, and it forms the basis for assessing the sGSL foraging habitat and its vulnerability to future change.

S13-17253 Oral (ECOP)

Contribution of *Calanoides acutus* to the Southern Ocean lipid pump: data mining, parameterisations, and modelling

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Calanoides acutus is one of a very small number of true diapausing pelagic zooplankton species in the Southern Ocean. During its 1 to 2 year life-cycle, it overwinters at depths sometimes in excess of 1000 m where it metabolises much of its carbon-rich lipid reserves. This process, known as the lipid pump, can release substantial amounts of inorganic carbon at depth and so contribute to carbon sequestration. The great depth of this carbon release means that the duration of sequestration may be decades longer than from other ecological processes such as gravitational sinking and active flux. Estimates of the extent of this lipid pump in carbon sequestration depend on parameterisations of the *C. acutus* life-cycle, but there remain large uncertainties in terms of its biomass and distribution, overwintering depth, timing of seasonal descent, overwintering metabolic rates, and interactions with the benthos. In this presentation, we will describe the progress made by two multinational programmes, BIOPOLE and PolarRES, on improving these parameterisations and projecting change under future climate scenarios. This will include a description of datasets that are presently available and how they may be employed to improve parameterisations. We provide an overview of modelling approaches considering life-cycle traits, local scale factors, such as advection and interaction with bottom topography, and global scale implications. We also describe our use of down-scaled high resolution climate models to project future changes in biomass and distribution across the Southern Ocean. Finally, we illustrate how modelling efforts are focussing the objectives of future field campaigns.

S13-17288 Oral

Stepping towards a mechanistic representation of the seasonal lipid pump in global ocean biogeochemical models

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The 'seasonal lipid pump' (SLP) refers to the accumulation of carbon-rich lipids in the surface ocean by copepods during spring/summer and their subsequent remineralisation at depth over winter following ontogenetic vertical migration. This process potentially sequesters a significant quantity of carbon in the deep ocean and thereby contributes to the ocean's biological carbon pump. Efforts to globally integrate and quantify the scale of the SLP have so far been carried out by compiling observational data and empirical upscaling, and it is currently not represented in the global ocean biogeochemical models (GOBMs) that are used to project future ocean-climate interactions. The development of mechanistic parameterisations of this complex phenomenon for use in GOBMs is challenging because of major gaps in our understanding of the ecological and physiological processes involved. We will present an overview of our individual-based stoichiometric model of a high-latitude copepod which, for the first time, includes a stoichiometric representation of lipid reserves and thereby non-homeostatic biomass C:N at the whole-animal level. Model results indicate that both food availability and predation influence the optimal timing of exit from overwintering and that timing exit from diapause is crucial for successful propagation of a population from one generation to the next. This study is a first step towards developing a mechanistic representation of the SLP in GOBMs and highlights the need for improved understanding of lipid use by high-latitude copepods and the mechanisms and cues that drive exit from diapause in order to better constrain carbon fluxes in ocean food-webs.

S13-17303 Oral

Spatial distribution and population structure of *Neocalanus* copepods in the eastern subarctic Pacific during winter and spring 2022.

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Neocalanus cristatus, *N. plumchrus* and *N. flemingeri* are large calanoid copepods occurring in the subarctic Pacific and in its marginal seas where they often form the bulk of zooplankton biomass. They undergo extensive ontogenetic vertical migration down to 800 m or deeper for over-wintering diapause followed by spawning and rapid development in the mixed layer during spring–summer. *Neocalanus* copepods are important prey for mesopelagic fish, salmon, seabirds and baleen whales, serving as an important link between primary producers and higher trophic levels. We investigated spatial distribution and developmental stage structure of *Neocalanus* populations in the eastern North Pacific including Gulf of Alaska and the Alaskan Gyre during late winter-early spring of 2022 as a part of the International Year of the Salmon (IYS) program. *Neocalanus flemingeri* co-occurred with *N. plumchrus* at most stations, while *N. cristatus* was substantially less abundant in the central gyre. Younger C1-C2 *Neocalanus* copepodites predominated numerically in February, C4 copepodite abundance increased substantially in April indicating that their reproduction peaks occurred earlier in the season. The individual sizes and mass increased throughout the period of observations due to development and growth resulting in increased contribution of *Neocalanus* copepods to the total zooplankton biomass. Comparisons to the historical data indicate potential phenological shift towards earlier spawning and faster development of Neocalanus copepods in the eastern north Pacific.

S13-17415 Oral (ECOP)

Temporal and spatial distribution of calanoid copepod eggs in intertidal sediment of Tanshui Estuary, northwestern Taiwan

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Resting egg production is an ecological strategy for calanoid copepods to overcome environmental adversities. They remain viable and undergo delayed hatching, forming an ‘egg bank’ in the sediments and serving as a copepod genetic and biomass reservoir in aquatic ecosystems. This study aims to investigate the spatial and temporal distributions of different types (subitaneous, quiescent and diapausing) of calanoid copepod eggs in the intertidal sediment of Tanshui Estuary, a sub-tropical estuarine in northwestern Taiwan, from December 2020 to November 2021. Six sampling stations were designated on both the left and right banks of Tanshui Estuary, respectively. The number of total sediment eggs varied across seasons, with the highest occurrence in the autumn and the lowest in the spring. For spatial distribution, the average number of total sediment eggs was higher on the left bank than on the right bank in all seasons. Based on the results of *ex-situ* incubations, the abundance of subitaneous eggs exhibited similar spatial and temporal distribution trends as the total sediment eggs. While two calanoid species (*Sinocalanus laveidactylus* and *Acartia pacifica*) were found capable of producing quiescent egg and diapausing egg at the middle estuarine stations of Tanshui Estuary. The freshwater copepod *S. laveidactylus* enters the middle estuary from the upstream freshwater area, while the marine species *A. pacifica* enters the middle estuary due to tidal currents. These copepods experience stressors of salinity increase or decrease, subsequently produce quiescent eggs or diapausing eggs in Tanshui Estuary.

S13-17030 Poster

Diel and seasonal vertical migration of *Calanus helgolandicus* and *Neocalanus gracilis* in the deep southern Adriatic (NE Mediterranean)

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Vertical habitat selection of populations of *Calanus helgolandicus* and *Neocalanus gracilis* (CV and adults) from the open oligotrophic waters of the Adriatic Sea (~1250 m) at different temporal scales is described and compared. A total of 120 day-night samples were collected on a seasonal basis (from June 2020 to May 2023) using an opening-closing Nansen net at eight sampling depths. Vertical behavior differed among species: seasonal rather than diel vertical migration dominated for *C. helgolandicus*, while *N. gracilis* showed a classic diel vertical migration pattern throughout the year. *N. gracilis* is a typical mesopelagic species, with a core population at about 220 m depth. In September, the maximum of 0.65 ind./m^3 was measured in the 200-300 m layer in daily samples. In contrast, *C. helgolandicus* has two separate populations during most of the year: one at the surface, concentrated in the upper 100 m depth, and the deeper-living one below 400 m depth. The seasonal numerical peak of abundance (>4 ind./m^3) was recorded in May (800-1200 m layer). During the warmest period, the surface population of *C. helgolandicus* disappears, indicating oversummering, whereas during winter mixing it was found throughout the water column. In contrast to the typical diel vertical migration of *N. gracilis, C. helgolandicus* rose only at night during winter. The differential responses of these species to environmental factors provide a foundation for future research that will expand our knowledge of biological interactions, vertical transport of organic carbon, and copepod adaptations to future climate change.

S13-17355 Poster

Calanus hyperboreus seasonal migration – the early, the late and the transient

Katrin Schmidt[1], Angus **Atkinson**[2], Martin Graeve[3], Wilhelm Hagen[4], Barbara Niehoff[3], Astrid Cornils[3], Benoit Lebreton[5], Serdar Sakinan[6], Céline Heuzé[7], Nahid Welteke[3], Sabrina Dorschner[4], Robert G. Campbell[8], Simon T. Belt[1], and Hauke Flores[3]

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Lipid accumulation, descent to depth and overwintering in diapause are key traits of the *Calanus hyperboreus* life cycle. However, while the textbook scenario considers the population to reside for 8-9 months below 1000 m depth, a compilation of net sample data shows deviations from this pattern with substantial abundances in shallower waters and near the surface. Such whereabouts of *Calanus* is relevant for their population development, epi- and mesopelagic food webs and carbon sequestration, and potentially sensitive to climate change via light and/or food triggers. During the MOSAiC expedition (2019/2020; Central Arctic Ocean), we found a staggered descent, with ~40% of the adult-subadult population below 500 m depth by mid-August, another ~30% joining them by mid-September, and the remaining ~30% aggregating in subsurface- or Atlantic water layer. Isotope-, sterol- and fatty acid trophic markers show, in line with the seasonal succession, specimens sampled at depth had been feeding on sea ice biota and those at the surface more on pelagic flagellates. We tested three previously proposed theories to explain the observed delay in descent: (1) lack of lipid reserves, (2) lack of predators and (3) high buoyancy. Theory 1 had to be rejected as animals at surface did not differ in size, lipid- or wax ester content from those at depth, while theory 2 and 3 require further considerations. Animals in the cold surface waters showed a combination of high lipid content and high unsaturation, making them potentially highly buoyant when migrating into the 4°C warmer Atlantic water layer.

Session 14: The role of zooplankton (including Antarctic krill) in Southern Ocean ecosystems in a changing world: Integrating across scales, disciplines, and methods

Convenors:
Alexis Bahl (Canada), corresponding
Dominik Bahlburg (Germany)
Stuart Corney (Australia)
Nadine Johnston (UK)

Invited Speakers:
Kim S. Bernard
(College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, USA)

Southern Ocean ecosystem dynamics play a critical role in global processes and are thus crucial to implementing regional and global climate change mitigation and adaptation efforts. However, research challenges in understanding these ecosystems remain, including quantification of ecosystem variability, coordination of sampling and modelling methods, and robust projections of future ecosystem change at multiple scales - all of which are needed to support conservation and sustainable management decisions. This joint session, coordinated by the Integrated Marine Biosphere Research (IMBeR) regional programme, Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED), and the Scientific Committee on Antarctic Research Krill Expert Group (SKEG), aims to address these research challenges, focusing on Antarctic krill-centered systems in the Southern Ocean. This session will build on the strong modelling research network already developed between these initiatives over the past few years, bringing together new and innovative approaches in Southern Ocean research to develop ecosystem models that represent species dynamics across various spatial, temporal, and organizational scales in support of sustainable governance. The scope of the session will include i. Modelling Southern Ocean ecosystems and species in present and future environments: ii. Empirical ecological studies investigating zooplankton from individuals to populations; iii. Projections of ecosystem change; iv. Policy implications and decision-making, and v. Integrated understanding of natural and human systems interactions. Additionally, efforts that promote collaboration across scientific disciplines and generate links between scientists and fishery managers for the purpose of improving management are highly encouraged.

This session is supported by established researchers from ICED and SKEG and run by early careers researchers with an impetus to involve the next generation of early career researchers and support community-driven input. Our main objective is to develop concrete actions and mobilize research efforts to support the 5th International Polar Year and the United National Decade of Ocean Science Collaborative Centre for the Southern Ocean Region (DCC-SOR). Finally, we strongly encourage interested participants to also explore the related session, “Recent Advances in Global Euphausiid Ecology.”

S14-17029 Invited

The Omnivore's Advantage: Diet and the winter physiology of Antarctic krill, *Euphausia superba*

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Antarctic krill, *Euphausia superba* (hereafter "krill") plays a vital role in the Southern Ocean food web, mediates biogeochemical cycling, and is the subject of a rapidly growing fishery. Understanding the physiological adaptations of krill to their environment is essential for elucidating their ecological role and predicting their response to climate change. We investigated the influence of diet on the physiology of krill, shedding light on their ability to survive and thrive at a time of year when their food resources are limited. As omnivores, krill are known to consume both phytoplankton and other small zooplankton, but availability of food during the winter is variable, and often dependent on the presence of sea ice. With continued warming at the Antarctic Peninsula, it is unclear how a shift in the type and amount of food available to overwintering krill will affect their physiology and condition. Over three austral winters (2019, 2022 and 2023), we conducted ~5-month feeding experiments with krill collected in May-June each year from the Gerlache Strait. Krill were subjected to different diets and their physiological rates and various fitness metrics were measured at monthly intervals. We found that krill fed a carnivorous diet had higher body condition, caloric content, and more lipids than those fed an herbivorous diet. In contrast, krill fed an herbivorous diet exhibited positive growth, while those on a carnivorous diet shrank. These findings were consistent across juvenile and adult krill, and suggest that an omnivorous diet is important for overwintering krill.

S14-17020 Oral

Zooplankton diversity with respect to biophysical processes in the Indian sector of the Southern Ocean

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Zooplankton plays a crucial roles in the cycling of carbon and nutrients, regulatingclimate, supporting primary and secondary production, maintaining biodiversity, food web configurations and balance among trophic levels and sustaining fisheries production, tourism and human communities. The information on zooplankton distribution and its role in ecosystem dynamics of southern Ocean and climate change has not been explored to be to be investigated with biophysical processes. The total zooplankton biovolume was mostly composed up of calanoids and cyclopoids, which accounted for 81% of the total zooplankton count. In addition to the copepods, chaetognaths and appendicularians were found to be the next most abundant taxa, showed their importance in the mesopelagic and bathypelagic layers. A total 19 species of zooplankton were identified from STF to PF through SAF. Nine species found in the STF and SAF included 7 common species, 13 species found in PF1 and SAF included 4 common species and 13 species found in PF2 included 4 common species with those in the STF and SAF. Between the surface and bottom of the MLD in the STF during 2013, *Oithona similis* had the highest abundance (259 N m^{-3}), followed by *Clausocalanus laticeps* (223 N m^{-3}), *Ctenocalanus citer* (101 N m^{-3}), *Calocalanus* sp. (91 N m^{-3}) and the lowest was *Microcalanus* sp.(52 N m^{-3}). Within the STF in 2015 through the MLD, *Oithona similis* was again the most abundant (351 N m^{-3}), followed by *Clausocalanus laticeps* (331 N m^{-3}), *Clausocalanus brevipes* (256 N m^{-3}), while the lowest abundance was *Metridia* sp.(19 N m^{-3}). The *Oithona similis* was also dominant (189 N m^{-3}) from the MLD to 200 m in the STF during 2013. The zooplankton biomass from surface to MLD region showed significant correlations between *Chl-a* concentrations of the frontal regions and was highest in the PF2 followed by PF1, SAF and STF. The zooplankton biomass showed the significant negative correlations between micro and picophytoplankton, and positive correlations with nanophytoplankton in PF2 and SAF. In other hand, the negative correlation between microphytoplankton and positive correlation to nano and picophytoplankton in PF1 and STF indicates the preferential food preys relationship between zooplankton and phytoplankton. Furthermore, many observational studies including this have resulted the important role of zooplankton grazing on controlling the phytoplankton biomass in the SO with respect to other biophysical processes and hence the long-term variations in the Indian Ocean sector of the SO should be regularly monitored to examine the effects of nutrient supply rates on the physiology of individual species/community structure as a whole, and on the global biogeochemical cycle.

S14-17021 Oral (ECOP)

Zooplankton as indicators of change in the Ross Sea ecosystem

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Zooplankton are an essential component of the Southern Ocean food web, as they connect lower trophic levels such as phytoplankton, to higher trophic levels up to fish, marine mammals, and seabirds.The Ross Sea is a highly productive ecosystem, yet zooplankton abundances are assumed to be comparatively low because of the decoupling of fast-growing phytoplankton from zooplankton. In addition, the pelagic community on the shelf differs significantly compared to the open Southern Ocean: the food web is based on crystal krill (*Euphausia crystallorophias*) and Antarctic silverfish (*Pleuragramma antarctica*), rather than Antarctic krill.

Here, we present zooplankton observations from four previous Antarctic voyages on the RV Tangaroa to the Ross Sea since 2018, covering both open waters of the Southern Ocean and the Ross Sea shelf region. Selected meso- and macrozooplankton species, including pteropods, amphipods, krill, and salps as well as juvenile silverfish were analyzed for their stable isotope composition to understand their role in the Ross Sea food web. Antarctic krill (*Euphausia superba*) and salps (*Salpa thompsoni*) were selected to compare interannual changes in the energy flow through the food web, which allows the description of ecological differences between years and prediction of future developments under the impact of climate change. Finally, we will discuss if the species can be used as indicators for the effectiveness of the Ross Sea MPA and its current spatial boundaries to inform the management of the Ross Sea region.

S14-17033 Oral

Developing a Krill Stock Hypothesis to inform krill fishery management in Southwest Atlantic Sector of the Southern Ocean

So **Kawaguchi**[1,2] and Bettina Meyer [3,4,5]

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Development of a stock hypothesis is an important step for the improvement of fisheries management. SCAR Krill Expert Group (SKEG), on a request by the Commission for the Conservation of Marine Antarctic Living Resources (CCAMLR), initiated development of a Krill Stock Hypothesis (KSH) to inform the development of the new krill management strategy for the Southwest Atlantic sector of the Southern Ocean (CCAMLR Area 48). Through an initial Workshop SKEG gathered experts' opinion on the locations on essential aspects of krill biology such as spawning hotspots, nursery hotspots, adult krill hotspots in summer and in autumn/winter to develop first-cut KSH to be developed and refined into the future. A coordinated multidisciplinary approach by the krill research community such as collection of environmental and net sampling, molecular approach, and oceanographic modelling, to understand the connectivity between life stage hotspots and regions are urgently required to improve the understanding of spatial population structure and krill flux. This will help updating KSH as a living document and greatly contribute to CCAMLR's krill fishery management.

S14-17034 Oral (ECOP)

Zooplankton variability around the sub-Antarctic Prince Edward Islands and the influence of the environment.

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Oceanographic conditions around the sub-Antarctic Prince Edwards Islands (PEIs) are characterized by high mesoscale variability and cross-frontal mixing. Bongo nets (200µm) were used to sample the zooplankton community in the upper 200m along routine monitoring transects during the 2018 and 2019 autumn cruises to re-supply the PEI research base. Zooplankton abundance and biovolume were assessed using a ZooScan with ZooProcess software, and images were validated using EcoTaxa. Temperature, salinity, and chlorophyll-*a* were sampled *in situ* in 2018 only, but daily reanalysis and satellite data were used to identify positions of fronts and mesoscale features in both years. In 2018, 2 cyclonic eddies interacted with the PEIs and the southern branch of the sub-Antarctic Front (S-SAF) was located south of the archipelago. In contrast, the S-SAF was closer to the PEI shelf in 2019. Both years showed similar zooplankton abundances (2018: 527.84 ind.m^{-3}; 2019: 571.94 ind.m^{-3}), but the mean biovolume in 2018 (200.76 $mm^3 \cdot m^{-3}$) was significantly higher than in 2019 (74.72 $mm^3 \cdot m^{-3}$), suggesting a higher abundance of larger organisms in 2018. Copepods dominated zooplankton abundance (>90%) in both years, whereas the biovolume was largely made up of Chaetognaths (2018: 44.9%; 2019: 39.2%), Copepods (2018: 33.9%; 2019: 35.7%) and Euphausiids (2018: 14.0%; 2019: 6.3%). Peaks in zooplankton abundance and biovolume corresponded with elevated chlorophyll-*a* (chl-a), but only biovolume was significantly correlated with chl-a. Our findings revealed the significant influence of mesoscale features like eddies and fronts on the spatial distribution and magnitude of zooplankton abundance and biovolume around the PEIs.

S14-17088 Oral

3-D habitat suitability models for salps and krill in the Southern Ocean

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Poleward distribution shift is a well-known marine species response to climate change and has been documented for various trophic groups in the global ocean. Circum-Antarctic habitats of the pelagic tunicate, *Salpa thompsoni*, and Antarctic krill, *Euphausia superba*, were modelled using presence data from many multi-year data sets. An ensemble species distribution model (species range envelope, non-parametric probabilistic ecological niche, boosted regression threes and maximum entropy model) were implemented using multivariate environmental parameters from the GFDL (Geophysical fluid dynamic laboratory) earth system model to obtain the 3-D distribution of the habitat suitability of krill and salp species. Habitat shifts and overlap of both species and their potential contemporary and projected overlap were investigated under two representative concentration pathways: RCP2.6 and 8.5. The overlap distribution of salps and krill appear to be important in the Atlantic (Scotia Sea), Indian Sectors of the Southern Ocean and in coastal regions, except the Ross Sea. Both species showed poleward shift in distribution under climate change scenarios, which was more pronounced under the no climate mitigation scenario. Projection demonstrated that the habitat overlaps increased under both scenarios in areas closer to the Antarctic continent suggesting a potential increase in competition for limited space between both species.

S14-17109 Oral (ECOP)

Acoustic signature of faecal pellets from Antarctic krill (*Euphausia superba*)

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Sedimentation by sinking zooplankton faecal pellets forms a key link in the sequestration of carbon via the Biological Carbon Pump and provides an important source of organic matter to benthic communities. With a large circumpolar biomass, the fast-sinking faecal pellets released by Antarctic krill are thought to contribute significantly to carbon export and nutrient cycling in the Southern Ocean. To date, sediment traps have been used to quantify the flux of faecal pellets to depth and while this technique provides important temporal resolution, its spatial resolution is limited. Active acoustics, as used in krill biomass surveys, offers an opportunity to isolate acoustic echoes produced by both krill and faecal pellets across a broad spatial scale; however, the acoustic echo of faecal pellets must first be determined. In this study, we measured the *ex situ* acoustic echo of krill faecal pellets relative to their length, orientation and sinking velocity using a 333 kHz echosounder. We compare the acoustic signature of loosely-packed faecal pellets (as produced from superfluous feeding), with densely-packed pellets (as produced under reduced food availability). Using these observations, we assess the feasibility of detecting faecal pellets from krill swarms *in situ* with using existing acoustic data. This work represents a first important step towards our ability to measure both krill biomass and faecal pellet production from ship-based echosounders. Quantifying the spatial variation of faecal pellet flux to the seafloor will increase our ability to accurately model sedimentation and carbon export around Antarctica under present and future climate scenarios.

S14-17113 Oral (ECOP)

Using novel methods to detect ecological changes in zooplankton communities of the Southern Ocean.

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In the last 50 years, the Southern Ocean has been facing a rapid shift in environmental conditions and ecology due to anthropogenic pressures, including climate change. These environmental changes are likely influencing the distribution and abundance of zooplankton communities. Due to the complexities associated with zooplankton communities and their ecology, they are difficult to monitor for detecting changes at the community level. To simplify the process and to focus on finding novel methods of detecting ecological changes in the species communities of the Southern Ocean, we focused on the euphausiid (krill) community as they are the most studied group of zooplankton taxa in this region. While some krill species have been extensively studied, we still lack information about the distribution of many non-endemic Southern Ocean krill species and their interactions as a community. We used the long-term and extensive SO-CPR (Southern Ocean-Continuous Plankton Recorder) data set as the basis for simulating virtual krill communities to examine the effects of species and community attributes, data characteristics and statistical methods under various climate change scenarios. Simulations utilised prevalence and abundances, species interactions and responses to key environmental factors that were based on those observed and then modified to test a range of climate change scenarios. By successfully detecting changes in the virtual krill communities, this approach could be applied to detecting real-world changes in the krill communities of the Southern Ocean.

S14-17114 Oral (ECOP)

Fine-scale variability in krill transport pathways between the Western Antarctic Peninsula and South Georgia

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Antarctic krill (Euphausia superba) is an important species in the Southern Ocean ecosystem and forms a crucial part of the food web. Survival through their first winter is thought to be critically dependent on the presence of sea ice and is a key factor in the successful recruitment of young krill and in maintaining an abundant population of krill. As larval and juvenile krill grow and develop, they can be transported over a large distance with ocean currents or drifting sea ice. Given the predicted changes in sea ice associated with climate change, improving understanding of the factors influencing the recruitment success of krill populations has been highlighted as a major research priority. We use daily sea ice and ocean velocity fields over a 32-year period (1987 – 2018) from a global high-resolution ocean-sea ice model (ACCESS-OM2, resolution: 0.1 degree). Using Lagrangian particle tracking, virtual particles were released and were tracked for over 6 months (April to October). This allowed us to explore fine scale interannual variability in over-winter transport pathways from regions where krill are thought to spawn to where they are observed in large numbers when sea ice retreats. Our findings highlight prospective regions of overwintering habitat areas and their ultimate destinations, shaped by the dynamic interplay of sea ice and oceanographic variables. This research enhances our understanding of the ecological and economic significance of krill on a global scale, and will help to inform sustainable Southern Ocean krill management strategies in the context of climate variability.

S14-17119 Oral (ECOP)

Mapping encounters between krill fishing vessels and air-breathing predators

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The Antarctic krill fishery has expanded in recent years and this trend is likely to continue for the foreseeable future. This development has been the subject of much debate, and concerns have been raised about the potential negative effects of the fishery on krill and krill predator populations. While the impact of krill fishing on krill populations can be quantified using catch reports, less is known about the impact of krill fishing on krill predators such as baleen whales, penguins or seals. Here we present the first results of an effort to map direct encounters between krill fishing vessels and air-breathing predators by analysing acoustic data recorded on three different krill fishing vessels. We trained a convolutional neural network capable of identifying diving, air-breathing predators in the acoustic recordings. After identifying the predators in the dataset, we derived a time series to analyse temporal and spatial trends in these encounters. We interpret these encounters as a metric of fishing vessel-predator interactions and provide the first quantitative description of such interactions. We hope that these findings will be a useful contribution to improved management of the krill fishery, which should aim to minimise such interactions.

S14-17161 Oral

Krill super-swarms provide important foraging grounds for whales near the Southern Kerguelen Plateau

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Antarctic krill are the keystone species of the Southern Ocean. Their swarms provide an energetically dense and often abundant food for whales and other predators. Krill super-swarm formations have been observed with 100s animals per cubic metre, 100s m long and 10 s m deep, but simultaneous observation of their 3D structure with cetacean observations has rarely been done. Here we describe the structure and biomass of an offshore krill super-swarm associated with large numbers of intensively feeding baleen whales in the Southern Kerguelen Plateau region (62°S 80°E). We suggest that super-swarms provide important foraging opportunities for migrating whales in the Southern Ocean. Super-swarms are rarely encountered in East Antarctica, but modern acoustic instruments – that sample large volumes of water 100s m from a vessel - super-swarms easier to find and so may be targeted efficiently by a krill fishery. Given the potential for overlap between whales and fisheries, we recommend establishing 'move on rules' to govern the fishing of super-swarms.

S14-17167 Oral

Effects of recent and unprecedented warming and low sea ice on zooplankton of the West Antarctic Peninsula

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The West Antarctic Peninsula (WAP) is a highly dynamic region of the Southern Ocean that has undergone significant long-term change due to increases in air and sea surface temperature, and decrease in sea ice cover. These changes significantly affect the marine pelagic ecosystem along the WAP, including shifts in abundance of the dominant zooplankton. In the last two years, however, the magnitude of warming and sea ice loss have exceeded any of our previous long-term observations. Our goal was to examine the effects of these unprecedented and anomalous conditions on the zooplankton community, using data from our ongoing (1993-present) Palmer Antarctica Long-Term Ecological Research (PAL LTER) program. The pteropod *Limacina rangii* experienced a population increase along the entire study area of a magnitude seen just once prior in the 3-decade-long time series, which was strongly related to warm, ice-free conditions characteristic of La Niña years. Conversely, large negative abundance anomalies in ice krill *Euphausia crystallorophias* (lowest recorded in the time series) and Antarctic krill *Euphausia superba* occurred in the southern part of our study region. Surprisingly, abundance of the salp *Salpa thompsoni*, known for its affinity with warmer, ice-free conditions did not increase significantly. We discuss these recent results in the context of predicted continued warming and sea ice loss in the WAP (e.g., will there be a disruption in the *E. superba* recruitment cycle?) and the implications for upper trophic levels and ecosystem management.

S14-17169 Oral (ECOP)

Understanding Krill Energy Budgets: Growth, Reproduction and Metabolic Adaptations in Response to Environmental Change

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Energy allocation is as important as energy uptake to maintain a healthy life cycle and a sustainable krill population. Field research has shown that the physiological functional response of krill to various food levels is different for the different phases of the life cycle. Environmental factors such as temperature also play important roles in the physiological performance of krill.

This study adapted an established 'Energetics Moult-Cycle (EMC) model' framework to investigate krill energy allocation and physiological adaptations under current and projected temperature scenarios, coupled with potential changes in food availability. The refined model particularly focuses on the use of protein and lipid for energy assimilation and allocation by krill. Initially, we explored the model's output for krill growth, metabolism, and reproduction using environmental information based on observed satellite data around South Georgia Island, focusing on two primary nutritional pathways (lipid and protein). Subsequently, we examined how krill physiology may change under projected warming scenarios, such as SSP2-4.5 and SSP5-8.5, by the end of this century.

Our preliminary results showed the model's effective regulation of energy distribution among various physiological functions, distinctly channelling energy from lipid and protein sources. These results align reasonably well with field observations. Also, under future conditions, our model suggests a lower fecundity at higher ages (3+ years) under high-emission scenarios. Moreover, the model suggests that increased future temperatures and disparate seasonal changes in phytoplankton carbon will adversely affect krill growth.

S14-17170 Oral

Using environmental DNA (eDNA) for monitoring in the Southern Ocean: understanding limitations and opportunities

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Environmental DNA (eDNA) based methods detect DNA shed into the environment by organisms living there. This can be used to characterise biodiversity, or to detect the presence of individual species of interest. We aim to incorporate eDNA-based methods into Southern Ocean biodiversity monitoring.
As a relatively new monitoring approach, we need to understand variables that influence eDNA data interpretation in Southern Ocean ecosystems. For example, without an understanding of how long eDNA remains detectable in ocean currents it may be difficult to use eDNA methods to understand spatial and temporal boundaries of species distributions. It is also important to understand how best eDNA methods can augment existing monitoring approaches.
To assess the usefulness of eDNA-based methods for biodiversity detection, we conducted eDNA surveys alongside established continuous plankton recorder surveys (a long-term marine monitoring program). We compare results and discuss the strengths and challenges of each survey method.
To demonstrate the potential of eDNA-based methods for targeted species monitoring, we developed a species-specific assay to detect Antarctic krill from water samples. To investigated how long krill eDNA remained detectable in water samples and how that eDNA degraded over time, we carried out an aquarium experiment. Based on the results, we developed a method to determine the time since eDNA was shed based on fragmentation of the krill eDNA and applied this method to field surveys. In this presentation we summarise our findings and make recommendation for robust eDNA-based monitoring in the Southern Ocean.

S14-17258 RecordedOral (ECOP)

Distinct diurnal and seasonal variation in the distribution of Antarctic krill (*Euphausia superba*) during austral winter

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Euphausia superba (Antarctic krill) is a key component of the South Georgia ecosystem, supporting populations of higher predators including seabirds, seals and whales. It is also the focus of a commercial fishery which operates exclusively during winter. Little is currently known about the distribution or ecology of krill or krill predators during this period, impeding effective evidence-based management of the fishery and ecosystem. Addressing this gap is the focus of a multidisciplinary project combining krill and predator surveys during austral winter. Here, we report results from one year of surveys. In 2022, three areal acoustic surveys (day and night) were conducted in May, July and September. Krill swarms were identified using the CCAMLR swarms-based method. Mean krill areal biomass and density in the area used by the krill fishery were estimated. Based on combined day and night transect data, biomass declined from 268,521 tonnes in May; 249,822 tonnes in July; to 76,828 tonnes in September. Density declined from 45.3 g m^{-2} to 42.1 g m^{-2} to 13.0 g m^{-2} over the same period. However, significant diurnal and seasonal variability in biomass and vertical distribution was also observed, with biomass estimates for July and September highly sensitive (more than May) to whether daytime or night-time transects were used. Similarly, krill was observed deepest and closest to the bottom during daytime in July. These results illustrate that our knowledge of krill ecology in winter is incomplete and cannot be extrapolated from summer observations. Moreover, this has important implications for management and conservation.

S14-17264 Oral

Developing a strategy for future Southern Ocean zooplankton research: knowledge gaps and research priorities.

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The first Marine Ecosystem Assessment for the Southern Ocean (MEASO) was an international collaborative activity which assessed status and trends of Southern Ocean ecosystems. It considered drivers of change, particularly climate change and related processes, at the level of species, food webs, and ecosystems and their services. In this presentation, we give an overview of key zooplankton taxa (including euphausiids, copepods, salps, and pteropods) in terms of their ecology and roles, and observed changes at a circumpolar scale, based on a synthesis of available knowledge. An analysis of environmental suitability (modelled abundance) is given for some of these taxa over the past two decades based on samples collected by the international Scientific Committee on Antarctic Research (SCAR) Southern Ocean Continuous Plankton Recorder Survey (SO-CPR). We provide a qualitative assessment of potential futures for these key taxa in response to anticipated changes in key global and local drivers that we consider important for these taxa. We also assess their potential resilience focusing on the mechanisms that may underpin resistance and recovery, which can either be at the individual or population level; an aspect that has not been widely explored for these taxa. We conclude by identifying current limitations and strategic directions for Southern Ocean zooplankton research to enhance marine ecosystem models for the region and developing robust projections of change. This information is key to improving our understanding of Earth System functioning that will further support policy makers in developing conservation and management strategies.

S14-17292 Oral (ECOP)

Cataloging past efforts to inform future priorities for modeling Antarctic Krill growth and development: a synthesis and conceptualization

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Experimental and modelling approaches have long supported our understanding of Antarctic krill (Euphausia superba) growth and population dynamics under various environmental, biological, and anthropogenic stressors, both at present and in the future. However, despite these efforts being directly utilized to manage the Southern Ocean Antarctic Krill fishery,

significant gaps in knowledge remain. This study, stemming from The Integrating Climate and Ecosystem Dynamics of the Southern Ocean's (ICED) Krill Modelling International Workshop held in May 2021, presents a two-part output aimed at reviewing and organizing all pertinent data regarding krill growth and development to identify gaps that require prioritization. The analysis focuses on three identified processes of krill life history: egg and larval development, spawning, and overwintering. Our approach involved a systematic review of existing literature encompassing these processes, resulting in the compilation of nearly 2900 data points from 225 distinct studies. Subsequently, we compared this dataset against three conceptual models designed to address specific facets of krill life history essential for making reliable predictions at both the individual and population levels. The alignment of these data points with conceptual model sub-components and various sources of mortality uncovered notable knowledge deficiencies. Particularly, our analysis highlighted a marked "low data status" pertaining to crucial mechanisms such as gonad development, molting, and overwintering. These gaps in information pose significant barriers to our comprehension of critical processes in the life history of krill. Such improvements are crucial for understanding how this species responds to the evolving environmental conditions and stressors prevalent in the Southern Ocean.

S14-17305 Oral (ECOP)

Harvesting long-term survey data to develop macrozooplankton distribution models for the Antarctic Peninsula

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Ocean warming and sea-ice decline are hypothesized to drive poleward redistribution of zooplankton in the Southern Ocean, but functional relationships between species density and regional oceanographic conditions are often uncertain. We combined 30 years of observations (1992 to 2023) from two survey programs to develop and evaluate predictive macrozooplankton species distribution models within the Antarctic Peninsula marine ecosystem (60° S to 70° S, ~400,000 km^2). We adapted a conceptual modeling approach from the California Current ecosystem that integrates bathymetric and satellite oceanographic data to predict species density. Euphausiids, amphipods, pteropods, and salps exhibited latitudinal and cross-shelf abundance gradients that structured zooplankton species composition. Each species was associated with distinct pelagic and coastal habitat conditions that varied spatially and annually. Though multi-decadal abundance changes were apparent in specific cases, sub-decadal fluctuations were the dominant pattern for individual species and for community-level composition. These patterns were consistent with regional climate variability along the Antarctic Peninsula since the early 1990s. Predictive models may become essential research tools for forecasting zooplankton composition changes as ship-based net sampling declines. We advocate for online mapping tools to allow sharing of zooplankton model predictions, and these forthcoming data products should contribute toward integrated assessment of the dynamic Antarctic Peninsula ecosystem.

S14-17409 Oral

Understanding variability in biochemical composition of Antarctic krill to address key biological questions.

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Antarctic krill are an important species in the Southern Ocean supporting most of the Antarctic birds and mammals. A sustainable krill fishery is developing with krill products used in aquaculture and increasingly for human consumption. The latter has emphasis on the unique properties of krill oil which includes high levels of the health-benefitting omega-3 long-chain ($\geq C_{20}$) polyunsaturated fatty acids, including EPA and DHA and also high relative levels of phospholipids in the krill oil. A new omega-3 krill oil industry has emerged and is rapidly expanding. We are working together with the krill fishery to predict the factors governing oil levels and the biochemical composition in krill, including in terms of lipid class and fatty acid composition, which will help us understand growth, reproduction and recruitment. The collection of basic biological information on Antarctic krill, that traditional fisheries take for granted, is expensive and challenging because of their complicated life history and difficult habitat. Working with the krill fishing industry, we now have access to samples that are collected continuously all year over several years which constitutes a sampling effort that far outweighs all scientific endeavours we have undertaken to date. We will present a six-year data set showing variation in krill biochemical composition with respect to environment parameters. Establishing strong links between research, industry and management will ensure protection of this keystone species in the Antarctic ecosystem.

S14-17320 Poster (ECOP)

Probing ancient Antarctic krill populations

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Antarctic krill are vastly abundant crustaceans in the Southern Ocean, where they are a critical ecosystem component linking plankton to predators and contributing to biogeochemical cycles. Climate change, particularly warming, winter sea-ice habitat reduction and ocean acidification, as well as an increasing krill fishery, could lead to a population decline of this keystone species. To assess the potential impacts on krill population sustainability and resilience, studies investigating past records of environmentally driven krill population dynamics are crucial. To date, such paleo-studies targeting krill have been impossible, as krill leave no fossil records. However, with recent technological advances in sedimentary ancient DNA research (*sed*aDNA), such studies can now be realised. In fact, the application of *sed*aDNA analyses to reconstruct Antarctic marine ecosystems has already been shown, including the possibility to extract ancient DNA from crustaceans. This research will build on these already existing *sed*aDNA techniques and target Antarctic krill specifically. The latter will be achieved by applying an RNA based hybridisation-capture technique, a method that has been commonly used in ancient DNA research to capture very degraded and fragmented sequences. The capture approach will target krill for the first time, to investigate their dynamics over hundreds of thousands of years. This research will fill an important gap in our understanding of how Antarctic krill responded to past environmental change - knowledge that will improve predictions about future adaptation to ongoing climate change.

S14-17382 Poster (ECOP)

Lice capture on vessels of opportunity: a novel approach from longline fisheries.

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In recent years the Patagonian toothfish fishing industry has reported occasionally high prevalence of sea lice (amphipods and isopods). High abundance of sea lice can strongly reduce the availability of bait on longline hooks and attack fish caught on longlines. Therefore, sea lice have the potential to significantly impact the fishery by reducing both the catch rates and the quality of caught fish. Currently, little is known about sea lice species composition, distribution and abundance in the vicinity of Heard and McDonald Islands, and how they impact the fishery. Here we present the design, development, and use of new traps which can be deployed in conjunction with longline fishing to collect lice samples in the Southern Ocean from areas not otherwise available.

S14-17721 Poster (ECOP)

Effects of starvation and lipid removal on δ^{13}C and δ^{15}N profiles in krill tissues

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Stable isotopes of carbon and nitrogen are a routine tool used for trophic studies in aquatic environments. Stable isotopes can be influenced by food sources, fractionation within different tissues and organs, lipid content, and individual development stages. Antarctic krill (*Euphausia superba*) play a crucial role in the food web, connecting primary productivity with higher trophic predators in the Southern Ocean. However, it is not clear how the accumulation of δ^{13}C and δ^{15}N varies in different tissues and the potential impact of lipid removal and the consequences of starvation during food scarce periods. In this study, we investigated the effect of starvation and lipid removal on □^{13}C and □^{15}N profiles, as well as the carbon (C %) and nitrogen (N %) contents of krill tissues. Krill were either fed a controlled laboratory diet (*Gemingera criophylum* and *Pyramimonas geldicola*) or starved for ten weeks to quantify their tissue isotopic fractionation. Muscle and carapace tissues were collected at the beginning and end of the experiment. Eyeballs were collected every 1-2 weeks, and moults were collected daily and batched weekly. Our results revealed that krill eyeballs have a similar C and N content as krill muscle, while carapace and moults differ significantly from krill muscle. Starvation had no impact on the isotopes in the eyeballs but showed a significant effect on moults, leading to increased δ^{13}C and δ^{15}N after the fasting treatment. Lipid removal affected tissues and stable isotopes differently. Overall, lipid removal had statistically significant influences on the δ^{13}C and δ^{15}N of krill muscle, and a significant influence on the □^{13}C of the carapace in the krill. Understanding isotopic fractionation in krill tissues is crucial for accurately interpreting stable isotope data in trophic studies.

Session 15: Recent advances in global euphausiid ecology

Convenors:
Kim Bernard (USA), corresponding
Padmini Dalpadado (Norway)
Macarena Díaz-Astudillo (Chile)
Geraint Tarling (UK)

Invited Speakers:
Teresa Sofia Giesta da Silva (Marine and Freshwater Research Institute of Iceland)

Euphausiids (krill) are a critical component of global zooplankton communities. They play a key role in pelagic food webs as consumers of lower trophic-level organisms and as prey to numerous top predators, including commercially important fishes, marine mammals, and seabirds. Euphausiids also contribute to the biogeochemistry of the global oceans through the cycling of elements including carbon, nitrogen and phosphorous. Furthermore, they can act as a major conduit for carbon export and sequestration to the deep ocean. Although euphausiids share traits that make them extremely successful, recent studies have shown clear impacts of climate change and other anthropogenic stressors (including warming, ocean acidification, deoxygenation, and pollution) on euphausiids, globally. In this session, we invite researchers to present their recent work advancing our understanding of euphausiids in any of the world's oceans. This work can focus on, but not necessarily be limited to, (1) universal traits of euphausiids that contribute to their success (e.g., swarming, reproductive strategy, continuous molting, DVM), (2) niche separation and overlap between euphausiid species, (3) biogeographic patterns and environmental drivers thereof, (4) parasites and pathogens, (5) evidence of climate change impacts, (6) impacts of anthropogenic stressors, (7) trophic ecology and food web dynamics, (8) role in biogeochemical cycles and carbon sequestration, and (9) advances in technology for studying euphausiids (from molecular to remote and autonomous sensing). While we also invite research on Antarctic krill, we note that there is a session on "The role of zooplankton (including Antarctic krill) in Southern Ocean ecosystems in a changing world: integrating across scales, disciplines, and methods". Thus, we encourage interested participants to explore both sessions.

S15-17261 Invited (ECOP)

New insights into the ecological role of krill in the Icelandic marine ecosystem

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Krill have a pivotal role in the Icelandic marine ecosystem as conveyers of mass from the low to high trophic levels. Krill are a crucial food source for commercial fish stocks, marine mammals and seabirds. Understanding the krill population dynamics is of great importance, as fluctuations in krill abundance can greatly impact the abundance and distribution of species at higher trophic levels. First, we present results from the recent ecological studies on long-term changes, distribution and drivers of krill in Icelandic waters. The results show a significant decline in the mean abundance of krill from 1958 to 2007 in the oceanic waters south of Iceland. It is hypothesized that weakened synchrony between the development of young krill and the onset of the phytoplankton bloom induced by recent climate warming may have led to the observed decline in krill abundance. We also present results on the distribution of eggs, larvae and adult abundance around Iceland into three oceanographic domains and phytoplankton spring bloom dynamics around Iceland. *Meganyctiphanes norvegica* was mainly associated with Atlantic water, while *Thysanoessa inermis* was found evenly distributed around the island, while the higher values were found southwest for this species. Finally, we will also show the most recent research focusing on the distribution of acoustic backscatter of krill recorded down to 300 m from 2011 to 2023 during spring.

S15-17042 Oral (ECOP)

Krill swarms offer variable energy density to predators in the Northern California Current system

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In the Northern California Current (NCC) ecosystem, part of a productive Eastern Boundary Upwelling System, krill provide crucial ecosystem services including transferring energy from primary production to higher trophic levels. The region's dominant species, *Euphausia pacifica* and *Thysanoessa spinifera* (hereafter "krill"), support a diverse group of predators including fish, seabirds, seals, and whales. The quality of these species as prey depends on a myriad of factors including the time of year, variable ocean conditions, and the characteristics of their aggregations. Describing and quantifying the variability of krill as prey is key to understanding regional foraging ecology of top predators. In this study, we used multi-frequency active acoustic backscatter data collected during 20 days of survey effort in May and September 2022 to isolate the backscatter signal of krill and characterize the size, packing density, and depth of their aggregations (n = 684). In addition, we quantified the caloric content of individual *E. pacifica* (n = 179) and *T. spinifera* (n = 86) using bomb calorimetry. These data reveal spatial and seasonal patterns in krill aggregation structure, and variability in krill caloric content based on species and season (pre- or post- summer upwelling). Together, these results illustrate the dynamic nature of krill as prey in the NCC, and the factors that may influence the value of these important animals to predators around the globe.

S15-17046 Oral

Krill morphological differentiation. I.- A comparison of Somatic Length relationships for Eastern tropical north Pacific, California Current and Antarctic species.

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Euphausiids samples obtained in different areas, were analyzed to understand the possible differences on development patterns, and sexual morphological differentiation. *Euphausia superba*, *Euphausia pacifica*, *Euphausia distinguenda* and *Euphausia diomedeae*, from the *Euphausia* genus, and *Thysanoessa spinifera, Thysanoessa macrura*, from the *Thysanoessa* genus, and *Nyctiphanes simplex*. Here we analyze the body proportions for each species, using 4 different measurements and the Differentiation Index (DI, Färber Lorda, 1990; Färber Lorda and Ceccaldi, 2020). Simple regressions were obtained, and they showed a different pattern of morphological differentiation, for each genus. Following that evidence, multivariate analyses were performed, confirming these findings. A new concept is here proposed, the mean Differentiation Index difference between males and females, here called ΔDI, for each species, was obtained, mean values for the species obtained in each area was related to the mean temperature and the mean sigma T values, obtained for the first 400 m layer in each area. For the Sigma T values, they follow the same trend as the ΔDI, and opposed to temperature. Antarctic *E. superba* showed the greatest differences between males and females, and especially between Males II and females. For the *Thysnoessa* genus the trend followed a different pattern. Other factors may influence these differences; probably higher lipids contents which helps in buoyancy, and different sexual reproduction seasons of the different genera may produce other development patterns in the *Thysanoessa* genus, as for the *Nyctiphanes* genus we do not have a possible comparison with another species from the same genus.

S15-17055 Oral

A new method for sampling the biology of the surface ocean - RSV Nuyina's wet well sampling system

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Australia's new Antarctic research and supply vessel, RSV Nuyina, has been equipped with a novel sampling system for krill, plankton and sea ice flora and fauna, the Wet Well. The system is an improvement over traditional trawling and net sampling in terms of the specimen quality achievable, delivering live research specimens from the surface ocean either in open water conditions or from under sea ice, without any ship time cost. This talk will identify the scientific drivers that led to the creation of this system and illustrate how the system can operate to deliver high quality specimens in a matter of seconds from the ocean. The results from the first Antarctic commissioning voyage will be presented along with details of the associated aquarium infrastructure and the intended direction for future development.

S15-17060 Oral (ECOP)

The wide distribution of *Euphausia* species in the low-latitude ecosystem supported by the flexible omnivory: two cases in the low-latitude Indian and Pacific Oceans

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The feeding ecology of euphausiids was seriously overlooked in the low latitudes. Here, we revealed the feeding ecology of *Euphausia diomedeae* and *E. brevis,* which were the most abundant and widely distributed euphausiid species in the tropical eastern Indian Ocean (EI) and the North Pacific subtropical gyre (NPSG), respectively. DNA metabarcoding-based gut content analysis showed that both species displayed an omnivorous diet, mainly including Dinoflagellata, Stramenopiles, Hacrobia, and Copepoda taxonomic groups. Viewing from the dominant prey operational taxonomic units of two species, *E. brevis* from the NPSG of lower primary productivity (PP; < 0.25g C / m^2 / d) fed primarily upon Clausocalanidae, Lucicutiidae/Metridinidae, and Sphaerozoidae. Differently, *E. diomedeae* experiencing a significantly higher PP level (average 0.93 g C/ m^2 / d) interacted more directly with PP, relying on phototrophs such as Pelagomonadales, Bacillariaceae, and chlorophytes. Moreover, both species presented a remarkable regional diet variation triggered by food availability changes. Due to the locally lower copepod density, *E. brevis* reduced copepod intake in the western NPSG. Similarly, *E. diomedeae* ingested more microalgae in the southern EI than in the northern. Concomitantly, their varied diet was verified by the stable isotope analysis: *E. brevis* demonstrated a relatively lower trophic level (TL) in the western NPSG (2.5±0.2; 3.3±0.2 for eastern); the mean TL of southern EI *E. diomedeae* (2.7±0.1) was significantly lower than that of the northern ones (3.3±0.3). These results indicate that omnivory facilitated E*uphausia*'s prevalence in the oligotrophic ecosystem, and the PP level potentially controls their diet's autotrophic/non-autotrophic prey proportion.

S15-17073 Oral

Varying individual swimming behavior of the krill *Meganyctiphanes norvegica*

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Autonomous echosounders deployed within acoustical scattering layers of the krill *Meganyctiphanes norvegica* resolved individual behavior. The krill swimming behavior varied throughout the year. At the end of the spring bloom period, individuals continuously traversed the krill scattering layer during the day, ascending straightly upwards, subsequently sinking in circles before repeating the pattern. Individuals appeared to traverse the entire vertical extension (~70 m) of the krill layer several times each day. We interpret this behavior as filter feeding on the sedimenting spring bloom. The continuous and extensive daytime vertical relocations exceeded the vertical swimming associated with DVM. Such behavior has implications for bioenergetics, will modify any individual size distribution by depth, and means that individual daytime habitat will encompass light levels several orders of magnitude. Later in summer and in winter, the krill were rather swimming in a vertical "zig-zag" pattern without much net vertical relocation. We hypothesize that this behavior reflects searching for prey while foraging as carnivores. A third pattern involved more horizontally aligned individuals. Such behavior appeared both at depth during the day, and as the krill formed patches during ascent in the afternoon and descent in the morning. We speculate that such swimming may favor predator avoidance. Predator avoidance was otherwise displayed by instantaneous escape reaction upon encounters with fish schools. The various behavioral patterns involved different acoustic backscatter properties of the krill with implications for acoustic abundance estimates.

S15-17084 Oral (ECOP)

Response of euphausiids in the southeastern Bering Sea to environmental variability between a recent cold (2008-2012) and warm (2014-2018) period

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The southeastern Bering Sea is currently experiencing an oscillation between multi-year warm and cold periods characterized by changes in water temperature, winter sea ice extent, and summer cold pool size. Changes in euphausiid populations in the southeastern Bering Sea between warm and cold periods have been observed in previous studies, but the response of euphausiids to climate variability in the region is not well understood. We examined the response of the dominant subarctic euphausiids, *Thysanoessa inermis*, *Thysanoessa raschii*, and *Thysanoessa longipes*, and two subarctic-transitional species, *Thysanoessa spinifera* and *Euphausia pacifica*, to changes in environmental conditions between a recent cold period (2008–2012) and a recent warm period (2014–2018) in the southeastern Bering Sea. Results showed that *T. inermis* and *T. spinifera* were significantly more abundant during the warm period, and *T. raschii* was significantly more abundant during the cold period. Species had specific geographic distributions, and the abundances of *T. inermis*, *T. raschii*, and *T. longipes* were related to sea surface temperature, while the abundances of *T. spinifera* and *E. pacifica* were related to the Pacific Decadal Oscillation. The population centers of all species exhibited a general northward trend in response to warmer conditions, but only three out of ten models were significant. The results provide evidence that the species composition, abundance, and spatial distribution of euphausiids in the southeastern Bering Sea differs between warm and cold periods. Our findings have implications for the southeastern Bering Sea ecosystem and fisheries.

S15-17136 Oral

Similar but different: phylogeography of the two co-occuring biantitropical krill species *Thysanoessa gregaria* and *Hansarsia megalops* in the Atlantic Ocean

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Thysanoessa gregaria and *Hansarsia* (former *Nematoscelis*) *megalops* are two abundant krill species occurring in the warm-temperate belts in the North and the South Atlantic. We assessed genetic diversity of the both species, patterns of their spatial genetic structure and demographic history using representatives from northern and southern populations. We analyzed variation of the mitochondrial cytochrome c oxidase subunit 1 gene (COI) and assumed that geographically isolated populations of each species should differ genetically. This is true for *H. megalops* in which the northern and the southern populations are significantly different (COI K2P=5.8%) and the southern population has lower levels of genetic diversity. Yet conversely, northern and southern populations of *T. gregaria* are genetically cohesive and demonstrate an unexpectedly high level of haplotype diversity. We consider biological and ecological traits of the both species in order to assess possible drivers shaping the difference in genetic structure of *T. gregaria* and *H. megalops*. Phylogeographic structure of other krill species merits further analyses in order to understand ecology, and mechanisms of diversification in this important group.

S15-17154 Oral (ECOP)

Contrasting responses of euphausiid species to environmental and biological drivers explain the low krill diversity of the Humboldt Current System coastal area

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The Humboldt Current System is a highly productive eastern boundary upwelling system. In its northern region (north of 30°S), upwelling is permanent year-round, sustaining high levels of biological productivity and some of the most productive fisheries worldwide. In this area, euphausiids compose a large fraction of zooplankton biomass and are a key component of food webs. We studied spatio-temporal changes in euphausiid abundance off northern Chile using *in situ* data from 16 bi-annual cruises (2010-2017) and identified the main drivers of species distribution and abundance using hierarchical generalized additive models. The first mode of environmental variability explained most of the variance in the community composition and was represented by upwelling-associated cross-shore gradients in temperature and dissolved oxygen. The second mode was related to ENSO variability in salinity. The endemic species *Euphausia mucronata* was the only one with higher abundances within 10 km from the coast, where temperature was lower and the oxygen minimum zone, shallower. The other 3 main taxa (*E. eximia*, *Stylocheiron affine* and *Hansaria* spp.) presented the opposite pattern. The acoustic biomass of the Peruvian anchovy (an important krill predator) had a negative non-linear effect on *E. mucronata*, and both shared their coastal habitat. Chlorophyll-a was an insignificant predictor for all taxa, suggesting food is not a limitation for krill in this area. These results suggest that *E. mucronata* is the only species fully adapted to live in the oxygen-deficient coastal band, thus, explaining the low diversity of coastal krill assemblages in this ecosystem.

S15-17175 Oral (ECOP)

Mapping distribution of Euphausiid species in the Southern Ocean using Continuous Plankton Recorder data

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Euphausiids (krill) play an important role in Southern Ocean and sub-antarctic food webs. They form the energetic link between primary producers in phytoplankton, and higher order predators such as fish, penguins, squid, whales and sea birds. Antarctic krill (*Euphausia superba*) are relatively well studied, and their overall life history and importance in the Southern Ocean food web is well understood. By comparison, other species of krill are understudied. Their importance to Southern Ocean food webs, together with the possible effects of environmental change on their biomass, range and movement patterns, remains largely unknown. Using data obtained from the Southern Ocean Continuous Plankton Recorder program (Australian Antarctic Data Centre and Integrated Marine Observing System - SOCPR), I mapped the distribution and abundance of four krill species (*E. frigida, E. similis, E. superba, E. vallentini*) across the Indian sector of the Southern Ocean. Presence/absence and total abundance were mapped against Southern Ocean fronts to track trends and changes in distribution and abundance over time. We discuss the potential factors influencing the boundaries present between species, including the role that fronts may play in determining distribution.

S15-17176 Oral (ECOP)

Comparing mesopelagic and epipelagic diet in *Euphausia superba* using two methods

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Antarctic krill (*Euphausia superba*) are an important species in Southern Ocean food webs. Krill exhibit diel vertical migration (DVM) and have been recorded in the mesopelagic and bathypelagic zones. In our research, we assessed the diet composition of two groups of *E. superba* using scanning electron microscopy (SEM), alongside detection of highly branched isoprenoids (HBIs), a biomarker that accumulates in pelagic grazers. Samples were taken from two sites on the TEMPO 2021 voyage. Site 1 was sampled using a midwater trawl; site 2 was sampled using a CTD mounted light trap deployed to the sea floor (380 m). Krill have been observed at this deeper depth but have not previously been sampled. The krill's gut contents were analysed using SEM to determine prey species and abundance. Historic continuous plankton recorder (CPR) records were used to determine potential food sources for the krill populations. Epipelagic krill were feeding heavily on the pennate diatom *Thalassiothrix antarctica,* while Mesopelagic krill were ingesting a wider range of diatoms. Both krill samples contained the ice-associated diatom species (*Fragilariopsis curta, Fragilariopsis cylindrus*). Feeding on sea ice species by the epipelagic krill was confirmed by the presence of HBIs. Our study highlights potential gaps in diatom species distribution data and suggests that krill found at deeper depths still consume ice-associated diatoms. Ours is the first study of prey species for *E. superba* sampled from the mesopelagic zone. Understanding prey species for krill found at deeper depths may broaden our understanding of Antarctic krill life cycles.

S15-17338 Oral (ECOP)

An Individual-Based Model (IBM) of Antarctic krill (*Euphausia superba*) swimming behaviour: From experimental observations to a working model

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Antarctic krill (*Euphausia superba*) are a vital component of the Southern Ocean ecosystem, with their swarming behaviours being key to their ability to forage and avoid predators. Knowing how environmental drivers change krill swarming behaviour is key to predicting their distribution and abundance for ecosystem models and fisheries management. An Individual-Based Model (IBM) was created for krill based on experimental observations taken under a range of different flow rates (0, 0.6, 3, 5.9 and 8.9 cm s^{-1}), light (surface and 100 m depth) and chemical cue (chlorophyll – a positive attractant and guano – a negative attractant) conditions. 3-dimensional tracks of krill were collected via video analysis and then used to generate the distributions and correlations seen within the model. A Random Forest model was used for each of the key swimming behaviour parameters (e.g., velocity, bimodal swimming, turn angles, edge effects, and pitch) to find which environmental variables had the greatest effect on each aspect of krill behaviour. A flat torus IBM was generated and ground-truthed to the observed data in control conditions before each environmental variable was added and the model expanded to include additional individuals and their interactions (such as nearest neighbour distance). The IBM will be scaled up and overlaid onto oceanographic models to predict krill swarming behaviour and dynamics. This is the first time that krill behaviour has been used to elucidate the dynamics and swarm structure of krill. Our IBM will greatly improve current ecosystem models and fisheries management decisions in the Southern Ocean.

S15-17178 Poster

Current status of krill fishery operation in the Sanriku coastal area, Japan

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North Pacific krill (*Euphausia pacifica*) is caught commercially in the Sanriku coastal area from February to May (peak season is from March to April) and is currently the only krill species caught in Japan. Although the relationship between the formation of fishing grounds and environmental conditions is known fragmentally about the krill fishery, there are many unknowns about the actual operational conditions. Here, we examined the detailed operation conditions using operation records of commercial krill fishing boats in the Sanriku coastal area during the 2020, 2021, and 2022 fishing seasons. Locations of fishing ground were recorded by GPS loggers, and water temperature and depth sensors were attached to the top of the net mouth of the boat seine. The catch data (number of baskets) were also recorded for each tow of seine. Catch per unit effort (CPUE: catch/operation time) was used as an index of standardized catch. The water temperature of the krill catch was in the 3-8°C range at the target depth of the tow, and operations in 2022 were done mainly on the lower side of the water temperature range than in 2020 and 2021. In addition, operations in 2022 were conducted mostly in the inshore area, and not offshore as in the 2020 and 2021 fishing seasons. These differences between 2020/2021 and 2022 could be attributed to the fact that the impact of the Oyashio Current on the Sanriku coastal area was stronger in 2022 than in 2020/2021.

Session 16: Improving zooplankton representation in models

Convenors:
Jason Everett (Australia), corresponding
Maria Grigoratou (Mercator Ocean International)
Ryan F. Heneghan (Australia)
Daniel J. Mayor (UK)

Invited Speakers:
Wendy Gentleman (Dalhousie University, Canada)
Tyler Rohr (Institute of Marine and Antarctic Studies, UTAS, Australia)

Numerical models are crucial tools used to overcome some of the inherent limitations of field and laboratory experiments, disentangle the roles of various ecosystem drivers, test hypotheses and improve our understanding of marine ecosystems under a changing climate. Despite significant improvements in their representation over recent years – such as more functional groups, feeding strategies, or behaviours – zooplankton are still poorly represented in most numerical models. They are often limited to being used as a closure term for phytoplankton (top-down) or as a background resource grouped with primary production for fish (bottom-up control). Ultimately, this misrepresentation reduces our confidence in model projections of pelagic community structure, carbon flow from the surface to the ocean's interior and energy flow from plankton to higher trophic predators under modern and future climate conditions. To change this paradigm quickly will require genuine and increased interactions between observational, experimental, theoretical, and modelling disciplines.

The session invites contributions from everyone interested in improving the representation of zooplankton in models at all scales of space, time and complexity – including (but not limited to) field biologists, physiologists, ecologists, theoreticians, statisticians and modellers. Topics may include model parameterisation; approaches that aim to better represent the diversity of zooplankton traits and functions; case-studies or overviews of specifics model types (IBMs, biogeochemical, size-spectrum, ecosystem, empirical, mechanistic); models focussed on individual functional groups (e.g. gelatinous zooplankton, copepods); studies that highlight the importance of zooplankton in operational and/or stakeholder-oriented forecasting frameworks used for policy advice (e.g., climate scenarios, fisheries, habitat suitability, Marine Protected Areas, Digital Twin of the Ocean). We also welcome studies that emphasise the use of new types of observations (e.g., metagenomics, acoustics, imaging), identify data gaps and data meta-analysis efforts needed for improving model design, model-data comparison, and data assimilation.

S16-17072 Invited (ECOP)

Beyond Closure: Building a Paradigm where Grazing Pressure is Constrained in Biogeochemical Models.

Tyler **Rohr**

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For years, an open secret in marine biogeochemical modelling has been that zooplankton are considered a highly-tunable, closure term. This is because 1. Bottom-up phytoplankton growth parameters are much easier to measure empirically on a ship or in a lab, and 2. Modelers lack globally gridded, high resolution, time-evolving data sets of zooplankton biomass and grazing rates analogous to what satellites can provide for phytoplankton chlorophyl, biomass and NPP. Accordingly, recent work has shown that zooplankton grazing pressure may be the single largest source of uncertainty in IPCC CMIP6 simulations of the marine carbon cycle. In turn, overturning can result in dramatic discrepancies in secondary and export production, compromising our projections of the ocean's ability to feed a growing population and buffer a changing climate.

To close the gap, modelers need to move beyond treating zooplankton as merely a closure term and work to derive new observational products with which to constrain top-down grazing pressure. Here, I argue that while precisely parameterizing the zooplankton grazing and mortality formulation for the mean state of a patchy ocean may not be tenable without large-scale in-situ experimentation and the inclusion of higher trophic levels in BGC models, we can look towards observations of emergent properties to constrain them. I will present a portfolio of work from the remote sensing record, in-situ ship-board observations, empirical laboratory studies, 0D and 3D inverse modelling with which the next generation of model developers can, and should, use to constrain emergent top-down controls in marine biogeochemical models.

S16-17345 Invited

Harnessing the power of process-based modelling to advance zooplankton ecology

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Modelling has tremendous scientific value for zooplankton ecology. In particular, process-based, aka mechanistic, models are powerful tools that consolidate our understanding and hypotheses about how environmental factors influence biology, revealing what that synthesis implies. When outputs are credible, models can be used to estimate unmeasured quantities and predict responses to, for example, a changing climate. When models don't match the data, diagnosis of why not identifies critical knowledge gaps.

The true potential for such modelling to contribute insight has not yet been realized. This is due in part to challenges that include oversimplified model structures (e.g. most global models are missing life history traits such as reproduction and diapause), formulations for feeding and growth that are unrealistically parameterized, and uncertain mortality terms. It is also due to an under-utilization of model-to-model comparisons, aka sensitivity studies, that inform about what matters and what doesn't. Increased knowledge and data availability create opportunities to design, apply and analyze process-based models more strategically.

This presentation will showcase imaginative modeling studies that, even in the face of limited data, highlighted important unknowns and quantified the relative impacts of different drivers. Examples include models that examine (i) a diversity of physiology and phenology, (ii) connections between lower and higher trophic levels, and (iii) how metabolism and vertical migration influence ocean biogeochemistry, including the biological carbon pump. Moreover, advances rely on effective communication between modelers and empiricists. I also discuss ways for these groups to better work together to develop innovative and informative future applications.

S16-17022 Oral (ECOP)

Evaluating ACCESS-OM2 zooplankton biomass estimates using empirical observations

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In the Southern Ocean (SO) ecosystem, zooplankton broadly influence biogeochemical cycles, food web dynamics and energy flow. Therefore, it is important to understand how zooplankton biomass is responding to changing environmental conditions over a broad spatial and temporal scale to ensure effective management, monitoring and conservation of this ecosystem. However, the remote nature of the SO means in-situ sampling is costly and time-consuming. Modelling is a powerful tool for overcoming such limitations, as estimations of multiple parameters can be obtained over large scales at a relatively high resolution. The current version of the Australian Community Climate Earth System Simulator global ocean-sea ice model (ACCESS-OM2) includes coupled sea ice and ocean biogeochemistry (World Ocean Model of Biogeochemistry and Trophic-dynamics: WOMBAT model). The model outputs include daily mean zooplankton biomass (mmol N m-3), meaning it has great potential as a tool for understanding the drivers of zooplankton biomass variability in Antarctica. However, model outputs must first be evaluated using empirical observations to ensure the modelled estimates can be confidently accepted. This project evaluates ACCESS-OM2 zooplankton biomass estimates within the Indian Ocean sector of the SO. Zooplankton counts collected by the Southern Ocean Continuous Plankton Recorder survey (SO-CPR) were transformed into biomass estimates, before being compared to the values predicted by the model over the same time period and geographical extent. Ultimately, this project provides novel insight into the efficacy of ACCESS-OM2 as a tool for understanding important biological-physical interactions in the SO.

S16-17056 Oral (ECOP)

Climate-driven zooplankton shifts cause large-scale declines in food quality for fish

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Zooplankton are the primary energy pathway from phytoplankton to fish. Yet, there is limited understanding about how climate change will modify zooplankton communities and the implications for marine food webs globally. Using a trait-based marine ecosystem model resolving key zooplankton groups, we find that future oceans, particularly in tropical regions, favour food webs increasingly dominated by carnivorous (chaetognaths, jellyfish and carnivorous copepods) and gelatinous filter-feeding zooplankton (larvaceans and salps) at the expense of omnivorous copepods and euphausiids. By providing a direct energetic pathway from small phytoplankton to fish, the rise of gelatinous filter feeders partially offsets the increase in trophic steps between primary producers and fish from declining phytoplankton biomass and increases in carnivorous zooplankton. However, future fish communities experience reduced carrying capacity from falling phytoplankton biomass and less nutritious food as environmental conditions increasingly favour gelatinous zooplankton, slightly exacerbating projected declines in small pelagic fish biomass in tropical regions by 2100.

S16-17112 Oral (ECOP)

Extracting region-specific trait values of functional groups from a global zooplankton trait database

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Categorizing species into functional groups is useful in understanding the distribution of functional traits in observed communities and in designing the representation of species in models. In this study, we extracted trait information for 123 zooplankton species belonging to seven phyla which were commonly found in the Northeast Pacific. We selected 24 traits on morphology, biochemical composition, physiological rates, and behavior from a global zooplankton trait database. The trait space of the regional species pool was derived, and nine zooplankton functional groups were identified. We related the relative contribution of the functional groups in over 3,000 net samples collected from 1995-2014 representing four bioregions along the cross-shelf gradient of the Canadian NE Pacific area. Two omnivore-herbivore functional groups (current feeders and small brooding copepods) consistently accounted for majority of the abundance and biomass across all bioregions while the dominant large carnivore functional groups were bioregion-specific. We then related the seasonal and interannual variability of the functional group composition to the variability in community-level trait values. The less dominant functional groups had distinct ranges of biochemical composition and physiological rates suggesting that these groups nonetheless contribute to the differentiation of bioregions and the estimated community-level functioning in terms of respiration, excretion, and clearance rates. Through this case study, we discuss the potential sensitivity of models to the representation and parameterization of functional groups, and the possibility of evaluating models using trends of estimated community-level functioning based on a global zooplankton trait database.

S16-17117 Oral (ECOP)

KRILLPODYM: a mechanistic, spatially resolved model of Antarctic krill distribution and abundance

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Robust prediction of population responses to changing environments requires the integration of factors controlling population dynamics with processes affecting distribution. This is true everywhere but especially in polar pelagic environments. Biological cycles for many polar species are synchronised to extreme seasonality, while their distributions may be influenced by both the prevailing oceanic circulation and sea-ice distribution. Antarctic krill (krill, Euphausia superba) is one such species exhibiting a complex life history that is finely tuned to the extreme seasonality of the Southern Ocean. Dependencies on the timing of optimal seasonal conditions has led to concerns over the effects of future climate on krill's population status, particularly given the species' important role within Southern Ocean ecosystems.

Under a changing climate, established correlations between environment and species may breakdown. Developing capacity for predicting krill responses to climate change therefore requires methods that can explicitly consider the interplay between life history, biological conditions, and transport. The Spatial Ecosystem And Population Dynamics Model (SEAPODYM) is one such framework that integrates population and general circulation modelling to simulate the spatial dynamics of key organisms. We describe methodology for adapting SEAPODYM to create a novel model – KRILLPODYM – that generates spatially resolved, circumpolar estimates of krill biomass and demographics. The model combines krill life-history, ocean and ice circulation, and key habitat requirements to simulate krill spatial dynamics across its full life cycle.

Here, we present the first configuration and implementation of KRILLPODYM and discuss how this new model could be used to explore critical ecological questions addressing the influence of different environmental constraints on krill distribution, regional abundance and metapopulation dynamics, as well as, ultimately, how we might use the model to harvest scenarios and the effects of localised krill fishing on surrounding ecosystems.

S16-17155 Oral

Self-organisation of zooplankton communities produces similar food chain lengths throughout the ocean

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For over 50 years, the conceptualisation of low-nutrient oligotrophic systems having longer food chains and thus lower energy transfer to fish than their high-nutrient eutrophic counterparts has dominated. However, recent global assessments indicate global fish biomass could be much higher than previously thought, suggesting that our traditional understanding of food-webs may need to be revisited. Here, we challenge the paradigm by exploring the role of zooplankton in food-webs across the world's oceans. Using observed zooplankton size-spectra, and output from a size-spectrum model that resolves nine zooplankton groups, we conclude that food-chains in oligotrophic and eutrophic systems have similar lengths. We offer a compelling hypothesis to explain this emergent pattern: self-organisation of zooplankton groups across the global productivity gradient regulates food-chain length. We find that in oligotrophic systems the increased carnivory and longer food-chains are offset by relatively large gelatinous filter feeders eating the dominant small phytoplankton, resulting in shorter-than-expected food chains, but decreasing food quality for fish. Our findings highlight the pivotal role zooplankton play in regulating energy transfer. Better resolution of zooplankton in models will increase our ability to estimate global fish biomass and provide more-robust forecasts of nutrient and carbon cycling.

S16-17190 Oral (ECOP)

Predicting the global spatio-temporal variability of zooplankton from field observations using a statistical habitat model ensemble to evaluate Earth System Models' marine biogeochemical components.

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The representation of zooplankton in Earth System Models (ESMs) has significantly improved in recent years, enhancing our understanding of their biogeochemical impacts. However, due to the sparsity of field observations, evaluating the dynamics of the growth, production and seasonality of zooplankton functional groups modelled by ESMs remains challenging. To address this issue, statistical habitat models (SHMs) serve as powerful tools for extracting information from the observations and predict such patterns in unsampled locations. Here, we use an ensemble of five SHMs to model the relationships between mesozooplankton biomass observations from MAREDAT and a set of environmental predictors. These SHMs allow us to robustly predict global monthly climatologies of mesozooplankton epipelagic biomass concentration. Chlorophyll-*a* concentration is found to be the main environmental predictor, supporting the model's ability to capture the responses of zooplankton biomass to large-scale productivity spatial patterns. Comparing these climatologies to mesozooplankton biomass outputs from the marine biogeochemical model PISCES-v2, we find that both biomass distributions agree on their overall order of magnitude ($r_{pearson} = 0.69$, total epipelagic biomass: 137 TgC in MAREDAT-based climatologies vs 322 TgC in PISCES-v2), and both agree on the biomass seasonality ($r_{pearson} = 0.54$ for the months of maximal biomass). Thus, SHMs provide insights into the spatial distribution of zooplankton seasonal patterns, which was previously unattainable with non-interpolated observations. This work represents a step towards improving the assessment of zooplankton functional groups in ESMs as we anticipate that a Plankton-Functional-Type (PFT)-resolved version of this product would help to better evaluate zooplankton development in ESMs.

S16-17276 Oral

Pattern-oriented advances in an individual-based model for the North Pacific krill, *Euphausia pacifica*: improving realism and framing questions for future improvements

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Euphausia pacifica are the dominant krill species in the California Current Ecosystem (CCE) and play a central role in transferring energy from lower trophic levels to many ecologically, economically, and culturally important species of the CCE. Based on a time series of observations off northern California, we have shown that adult *E. pacific*a tend to be smaller during warm climate events (such as marine heatwaves), a pattern that has important ecological implications and has subsequently been confirmed elsewhere in the northern CCE. To better understand how the environment drives variability in adult size, we applied pattern-oriented modeling to develop an individual based-model (IBM) for krill growth dynamics with substantially greater capacity to produce trends in size of adult krill over seasonal and interannual time scales that match patterns observed in nature. Key advancements in the model include incorporation of temperature-dependent maturation and modifications to energetic submodels that generate realistic growth dynamics in juvenile and adult stages. Remaining discrepancies were improved by implementing phenomenological patterns of seasonal variability in krill energetics and food quality. These latter elements of the model represent ecologically plausible hypotheses that warrant empirical study. As support for a ‘prey quality’ hypothesis, we show that the sharpest discrepancy between modeled and observed size dynamics occurred during a massive, persistent harmful algal bloom. In its current form, the IBM marks a substantial improvement on previous models, and provides a tool for more realistically incorporating environmental effects on krill in dynamic models of the California Current Ecosystem.

S16-17289 Oral

Mechanistic representation of zooplankton trophic transfer in a changing climate

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Zooplankton physiological rates such as respiration and biomass turnover are expected to increase throughout the 21st century as a consequence of ocean warming. Changes in the rate of primary production and the associated elemental stoichiometry (e.g., C:N ratio) of autotrophic biomass will likely also occur, thereby affecting the quantity and quality of their prey, respectively. '*Metabolic stoichiometry*' is presented as a physiological framework that has been developed by theoreticians and empiricists to mechanistically examine how the interacting, multifarious effects of ocean warming will influence trophic transfer across the phyto-zooplankton interface in ocean biogeochemical models. After briefly introducing this framework, we will use it to revisit the long-standing question of 'carbon (food quantity)- or nitrogen (food quality)-limited growth in marine zooplankton?' Our results indicate that the growth of zooplankton throughout the 21st century will most likely be limited by the quantity of food available, although this outcome could be partly offset by increasing phytoplankton C:N ratio. We will finish by answering the same question from a different perspective through the use of a novel dataset that independently supports this conclusion.

S16-17334 Oral (ECOP)

Improving a coupled physical-biological ocean model based on a meta-analysis of *Calanus finmarchicus* vertical distribution in relation to environmental variables.

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Calanus finmarchicus is one of the most-studied zooplankton species in the North Atlantic in part due to its significant role in the development of many fish species of commercial interest. Over the past decades, vertical net hauls have been collected routinely to estimate the abundance and population composition of *C. finmarchicus*. In the present study, we carried out a meta-analysis based on a compilation of *C. finmarchicus* vertical distribution data and its relationships with environmental variables in the upper layer (0-200 m) of the North Atlantic Basin, collected during spring and summer seasons between 1971 and 2018. Overall, early stages (CI-CIII) were distributed significantly shallower than adults, and vertical distribution was strongly related to season and the development of the phytoplankton bloom. Subsequently, meta-analysis results from the Atlantic Subarctic Province (Longhurst et al., 1995) were used in simulations of the coupled physical-biological ocean model SINMOD to improve the representation of the vertical distribution of this species in the Norwegian Sea. This study improves the present understanding of this species in the water column based on a large data set and contributes to an improved understanding of ecosystem dynamics of the Norwegian Sea's lower trophic levels.

S16-17180 Poster (ECOP)

Using Ecopath with detail zooplankton groups to evaluate the effect of reductions of sea ice in the food web structure.

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Zooplankton, as secondary producers, are crucial in marine food webs. Yet, they are often oversimplied in food web models. Due to its essential role in Antarctic food webs, Antarctic krill, *Euphausia superba*, has been extensively studied, however there are gaps in understanding their interactions with sea ice, which is an important aspect of their life cycle. Additionally, other krill species - such as *E. crystallorophias* and *E. triacantha*, which are especially important for studying Antarctic food webs in regions where sea ice is seasonally present, have been overshadowed, limiting predictability for food web models due to limited high-resolution data. This is true not only for krill species but also for other zooplankton taxa, these are generally oversimplified in models but are yet important for understanding overall food web structure and function.

The overarching aim of this study is to incorporate high-resolution diet data collected with stable isotope analysis and DNA metabarcoding on krill (*E. superba, E. triacantha and E. crystallorophias*) and other important zooplankton taxa (pteropods, copepods, salps, among others) to provide a better understanding of zooplankton diets and integrate this data into a mass-balanced (Ecopath with Ecosim) food web model for East Antarctica. This will allow for enhanced predictions of food web response to environmental change, with a particular interest on identifying the possible effect of sea ice reductions on the food web.

S16-17204 Poster

Model-ready data products: Taking discrete zooplankton observations from the local to the global scale

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Zooplankton biomass observations have been collected globally for well over 100 years, yet most datasets have been unavailable or difficult to use by the research community. Many of these are small-scale datasets, but when combined, they provide zooplankton observations over a large spatial and temporal scale. We have collated >200,000 records of marine zooplankton biomass into a single database, from which we developed statistical models based on a suite of environmental variables including sea surface temperature, chlorophyll-a and depth, and adjusted for biases associated with different sampling methods. These statistical models were used to produce spatial maps as model-ready data products. These model-ready data products are publicly available at any spatial extent or resolution the user requires via an R-Shiny Application. The zooplankton database and associated model-ready products will be invaluable for global change studies, research assessing trophic level linkages, and for initialising and assessing biogeochemical and ecosystem models of lower trophic levels.

S16-17302 Poster (ECOP) CANCELLED

~~**Protists richness macroecological patterns in the epipelagic realms of the Southeast Pacific Ocean (SPO)**~~

~~Sonia Yáñez[1,2], Laura **Tavera**[1,2], Garen Guzmán[2], Nicolás Espinoza[2], Margarita Marchant[3] and Cristián E. Hernández[2]~~

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~~Macroorganisms's macroecological rules have been developed to describe large-scale distributional patterns and attempt to explain the underlying physiological and ecological processes behind them. However, the extent to which microorganisms follow these rules remains unclear. Therefore, a debate has arisen around the paradigm that everything is everywhere, but the environment selects; mainly in apparent continuous environments like the Southeast Pacific Ocean (SPO), where there is also a lack of information about the microorganism's patterns. We use the planktonic protists as a study model, aimed to determine the biogeographic patterns, identify the underlying ecological processes, and clarify whether its patterns resemble those described for macroorganisms. Our analyses were based on the niche theory Bayesian approach, an integrated nested Laplace approximation (INLA), and Generalized Additive Models to find species diversity distribution using large open-access ecological and physical-biogeochemical databases. As a result, two biodiversity hotspots were observed, associated with coastal and offshore regions in the central southern areas of SPO. The processes that mainly explain the pattern were turnover in the Chilean and Equator coasts, and nestedness in the Peruvian Coast. The observed richness was the highest correlated with N/Si ratio, Mixed Layer depth, and pH. The predicted richness hotspots are associated with nutrients and MLD, which could be explained by highly productive upwelling events in the SPO. In contrast, the negative correlation of predicted richness with the low pH is highly related to the calcareous tests effect. Our results support that microorganisms do not follow the general biodiversity patterns of macroorganisms, following their own underlying rules of biogeographic assemblage.~~

Session 18: General Session: Zooplankton production in the Anthropocene

Convenors:
David Green (Australia), corresponding
Cornelia Jaspers (mentor) (Denmark)
Sinja Rist (Denmark)
Abigail Smith (Australia)

This session is envisioned to accommodate papers that contribute to the overall scope of the Symposium, but which do not fit within a specific Theme session listed above. We encourage all studies, especially those dealing with new horizons in zooplankton productivity, ecology or life history, as well as studies explicitly focusing on adaptation to climate change pressures, effects of extreme events or ecosystem indicators in order to better understand the challenges facing our marine ecosystems in the future. Oral and poster contributions are welcome. This session will be co-convened by Early Career Ocean Professionals, supported by the organizing committees.

S18-17023 Oral (ECOP)

Zooplankton community in the newly lava deltas in the Atlantic Ocean

Inma **Herrera**, Adrián Torres-Martínez, Inés Sastre-Estarellas and Ricardo J. Haroun

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This research shows the first records on biomass, abundance and community structure of zooplankton in the vicinity of recently formed lava deltas off the coast of the island of La Palma, Atlantic Ocean. The potential temperature showed values beyond the common range for these waters, likely due to the thermal impact of the lava deltas. Copepods appeared as the dominant taxonomic group, representing 82.1% of the taxa identified. This was closely followed by eggs at 9.4%, gastropods at 2.4%, chaetognaths at 2.2%, ostracods at 1.3%, decapod larvae at 1.1%, and gelatinous organisms at 0.5% (including siphonophores, salps and ctenophores), with other molluscs, polychaetes, amphipods, appendicularians and fish larvae making up the remaining 1%. Both biomass and abundance showed spatial disparities, correlated with organism size and proximity to lava deltas. Gelatinous organisms were more frequent in distant waters and along the southern transect (Tr3). Taxonomic analysis highlights that copepods were the main contributors in the 200-500 µm and 500-1000 µm size classes, while gelatinous organisms and other taxa dominated in the >1000 µm size range. Fitty-three copepod species were identified, including Copepodites as the main copepod group. Abundant copepod taxa in lava deltas were consistent with those found around the Canary Islands, including Oncaea, Oithona, and Clausocalanus. The presence of Candacia, Oncaea, and Oithona can indicate proximity to hydrothermal vents. These results suggest that the distribution and structure of zooplankton could be influenced by the impact of deltas and increased temperature in the waters near the newly formed lava deltas.

S18-17047 Oral

A seasonal comparison of zooplankton vertical distribution in the OMZ of the Eastern tropical Mexican Pacific.

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Samples obtained with a MOCNESS net, and CTD information for two cruises, during different seasons, but during different years, were used to study the vertical distribution of zooplankton in the OMZ in the entrance of the Gulf of California. On the seven layers sampled (0-50, 50-100, 100-150, 150-200, 200-300, 300-400, 400-500 m), zooplankton was concentrated in the first 150 m, for both cruises, zooplankton was mostly not migrating through the water column. A 48 hours sampling period showed that most zooplankton groups stay above the oxycline, for both cruises; a difference of 1/24 was found between the 0-50 m layer and the 150-200 m layer, for the autumn 2009 cruise, and a difference of 1/18.32 between the 0-50 m and the 400-500 m layer for the spring 2018 cruise. In open-ocean, and for both cruises the oxycline was present at around 100 m; but it steadily rises from Open Ocean to the shelf, during the spring cruise. Our data revealed that mostly euphausiids are the vertical migrators inside the OMZ with the dominant species being for November 2009, the vertical migrator *Euphausia lamelligera*, followed by *Stylocheiron affine* a non migrant species. The mean biovolumes of the first 100 m was 3.12 times higher than the next 400 m sampled in the autumn cruise, and 2.28 times higher during the spring cruise. The mean biovolumes of the spring 2018 cruise was roughly half of the 2009 autumn cruise. Thus the same vertical distribution pattern was verified for two different seasons, even under quite different hydrographic conditions.

S18-17057 Oral (ECOP)

Pelagic community structure and seasonal changes of zooplankton at Sado Island, Sea of Japan: Comparison of the open sea and coastline

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Sado Island is located in the eastern Japan Sea and is the second-largest offshore island with various Japanese coastal landforms. The Tsushima Warm Current passes around the island. Sado Island hosts a rich variety of seasonally variable aquatic organisms and presents unique biodiversity. This study was conducted to understand seasonal zooplankton changes and how environmental factors affect them at Sado Island. Additionally, this study compared zooplankton community structure between the open sea and the coastline. A plankton survey was conducted monthly at 3 sampling stations off the northwestern coast from April 2022 to March 2023 and seasonally from April to September 2023. Wave action was higher on the northwestern coast than the eastern coast. Three additional sampling stations were also established on the eastern coast from April to September 2023. The zooplankton community comprised 216 OTUs in total. Coastal habitats had more diverse zooplankton than open sea. The greatest zooplankton abundance occurred in autumn along the northwestern coast, followed by spring. Veligers, nauplii, and small copepods were abundant in spring along the coast, whereas tunicates and radiolarians were abundant in summer in the open sea. Foraminiferans and appendicularians were abundant in autumn and winter. In spring, copepods and cladocerans were abundant off the eastern coast, while radiolarians predominated in summer. Cyclopoid, Calocalanus, and Evadne populations were positively correlated with DO, whereas Radiolarians (Acanthostaurus, Aulosphaera, and Acanthometron) were positively correlated with temperature. These results significantly enhance our understanding of zooplankton diversity in the eastern part of the Sea of Japan.

S18-17122 Oral

The trophic base of zooplankton: is recent ocean biogeochemical zonation the only one?

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Marine zooplankton is fully dependent on the phytoplankton and on the seasonal balance between production and consumption of organic matter. The most widely accepted partition of the ocean pelagic (Longhurst, 1995) is based on seasonal cycle of satellite-derived surface chlorophyll (Chl), mixed layer depth (MLD), surface nutrient field, and other factors. However, our view on seasonal cycles of Chl (a proxy of phytoplankton concentration) over the global ocean suggests an alternative view on the pelagic division.

We identify significant and nearly ubiquitous peaks of Chl (a proxy of phytoplankton) between 40º S and 40º N in the oceans and illustrate the global distribution of the peakiness (the presence of the peaks). We ran Generalized Linear Models to explain this and found two main drivers of the peakiness: the depth of the euphotic layer and the MLD. We found two important effects: (1) the peakiness-based zonation of the global ocean is incongruent to the Longhurst' zonation and (2) this zonation show a significant climate-driven trend in over last 15 years.

We prove that the chlorophyll peakiness is tightly linked to the peakiness of particulate organic carbon (POC) and thus determines a seasonal disbalance between production and consumption of organic matter. The zonation of the global ocean on the basis of the POC peakiness mirrors the zonation based on the Chl peakiness. The areas of the seasonal Chl and POC disbalance merit further studies and attention because they potentially influence the zooplankton to a great extent in all oceanic basins.

S18-17141 Oral (ECOP)

Diel changes in the distribution of zooplankton over a steep submarine canyon: Is there evidence of canyon-induced transport?

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Submarine canyons are topographic discontinuities where non-linear complex dynamics modify the flow along the isobaths, causing strong cross-shelf transport and topographic upwelling. Within canyons, advective transport can retain organisms and particles, especially when organisms modify their vertical distribution by vertical migrations. These processes enhance biological production and explain why canyons are often hotspots of biodiversity. The goal of this study was to describe the vertical and horizontal distribution of zooplankton over a narrow and steep canyon indented in the highly productive shelf off central Chile. A 28h experiment was carried out during the downwelling season. The water column was highly stratified, with a cold and fresh surface layer (of estuarine origin) in the upper ~10m, a warmer and saltier intermediate layer (10-60m), and a colder bottom layer (>60m) with similar salinity than the intermediate one. Acoustically-inferred zooplankton biomass was higher in the deep canyon area (>100m) than in the upper layers, coinciding with intense in-shore flow. In the intermediate layer, zooplankton was consistently more aggregated in the northern slope. Acoustic biomass was higher during nighttime than daytime, in agreement with diel vertical migrations. Stratified zooplankton samples were dominated by highly migratory groups (*e.g.* decapod larvae, mysidaceans, and copepods). Along- and cross-shore currents did not explain the higher aggregation in the northern slope. Our results suggest that deep in-shore transport of zooplankton occurs inside the canyon, which might contribute to increase zooplankton production in this area. Potential asymmetrical physical retention will be studied in the following stages of this project.

S18-17142 Oral (ECOP)

Interannual changes of ichthyoplankton assemblage structure off North-West Africa: insights from different nets

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The annual variation of ichthyoplankton assemblages collected by two types of plankton nets were analysed to identify their distribution patterns, diversity and assemblage structure with regard to environmental conditions. Plankton sampling, covering the southern area of the Moroccan Atlantic coast (21°N-26°N, Cap Blanc-Cap Bojdour) was conducted in November 2019 and November 2022. Sampling was done using a Bongo-net (405 µm; double oblique tows within the 0-200 m layer) and a Manta net (335 µm mesh size; surface tows). A total of 26 families were identified in Bongo net samples, whereas only 16 families were found in the neuston samples. The DNA barcoding was applied for some neustonic species to identify fish larvae that morphology could not identify. Eggs and larvae belonging to families Clupeidae and Engraulidae, represented by the sardine Sardina pilchardus and anchovy Engraulis encrasicaulis respectively, were the dominant taxa in the samples collected by both nets. Larvae of the families Soleidae, Myctophidae and Sparidae were observed mostly in the Bongo samples in both sampling periods showing high abundances and variable distributions along the study area. The ichthyoneuston was characterised remarkably by the presence of larvae belonging to other families such as Belonidae, Sparidae, Mullidae, Mugilidae in addition to Exocoetidae Hemiramphidae and Blennidae (<6% of the total abundance). Our findings, additionally, highlighted the influence of the spatiotemporal environmental variability on structuring the larval fish assemblages. Both hydrological and trophic variables may have played an important role in shaping the observed ichthyoplankton distribution patterns.

S18-17149 Oral (ECOP)

Distinct structuring of copepod communities in the oxygen minimum zone of the Eastern Tropical North Pacific

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Oxygen minimum zones (OMZs) are expected to expand in the near future as the ocean warms and ocean deoxygenation increases. OMZs encompass a complex ecosystem characterized by distinct relationships among zooplankton and their environment. The Eastern Tropical North Pacific (ETNP) represents a region with different water column oxygen profiles, including OMZs of different intensity and thickness. This setting provides a natural laboratory for characterizing environmental conditions structuring zooplankton communities within and around OMZs as well as the potential effects of deoxygenation on these communities in the future. Here, we examined vertical distributions of over 100 calanoid copepod species in the ETNP from 2007 to 2017 to characterize their association with dominant environmental zones, relationships that prevail across all taxa at different locations over time. Copepods and hydrographic data were collected in vertically stratified day and night MOCNESS (Multiple Opening/Closing Net and Environmental Sensing System) tows (0–1000 m) during three cruises from 2007 to 2017 at different ETNP locations. Utilizing cluster analysis, results showed distinct communities prevailed throughout the region even at these different times and places. Species composition of these communities was primarily related to specific depth and ecological zones (e.g., upper and lower oxycline), regardless of year sampled. These results highlight the broader geographic and temporal consistency of OMZ-associated communities. Given that OMZs are critical zones for oceanic carbon export and production for commercial fisheries, identifying the dominant environmental conditions structuring copepod communities in OMZs aids in understanding the ocean regions that could be most affected by increasing deoxygenation.

S18-17157 Oral

Zooplankton functional group as an indicator of ecosystem health

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Ocean health and sustainable development is a worldwide topic now. How to assess the condition of the marine ecosystem and find an indicator that represent the condition of the marine ecosystem is vital important. Zooplankton is very important in the food web and biogeochemical cycling, it can shape the structure and function of a marine ecosystem, but there are so many species of zooplankton in an ecosystem, the species composition and biomass are very complex, it is hard to identify and count them. We can use key species to indicate the condition of the ecosystem, it is relatively easier to investigate, but in many situations, it is not suitable to represent the condition of the marine ecosystem. Zooplankton functional group is capable to be an indicator to indicate the ecosystem health condition. It can be organized in different group according to size and function, such as gelatinous group, crustacean group, and protozoan group etc., it is also easier to get the information. Jellyfish group and crustacean group will represent different health condition of the marine ecosystem.

S18-17218 Oral (ECOP)

Life histories of common copepods in a nearshore marine environment, East Antarctica

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Antarctic copepods are an important resource in marine food webs, often dominating planktonic biomass. In coastal environments, copepods exhibit a range of life history strategies to thrive under conditions of extended sea ice coverage and pronounced seasonality in phytoplankton availability. Zooplankton tows and ice cores were collected near O'Gorman Rocks in the Vestfold Hills region of East Antarctica throughout 1993-1995. Specimens of *Oncaea curvata*, *Oithona similis, Paralabidocera antarctica, Stephos longipes, Calanoides acutus, Ctenocalanus citer,* and *Drescheriella glacialis* were identified, staged, and life history associations with environmental conditions described. Lipids were extracted for *O. curvata*, *O. similis* and *P. antarctica* showing storage of mainly wax esters by *O. curvata* and *O. similis* and accumulation of triacylglycerols by *P. antarctica*. Common life history strategies for the collected copepod species included: association with the landfast ice cover during part or all of their life cycle, phytoplankton bloom synchronicity, lipid accumulation, and offshore migration. Timing of reproduction and dependence on favourable ice conditions for several key species may lead to shifts in local zooplankton dominance as Antarctic sea ice conditions change.

S18-17231 Oral (ECOP)

Temporal dynamics in planktonic copepod composition: Interplay of Kuroshio Current and shallow hydrothermal vents in the waters off northeastern Taiwan across varied monsoonal periods

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The community composition of planktonic copepods in the northeastern waters of Taiwan were investigated by sampling during three different monsoonal periods in 2022. Zooplankton samples were trawled from surface seawater (1-2m) using a 200μm mesh zooplankton net from the nearshore and Kuroshio areas. A total of 99 copepod species were identified from 24 families and 49 genera including three orders Calanoida, Cyclopoida, and Harpacticoida. Among them, 35 species of copepods were recorded in three different monsoon periods. Results showed that planktonic copepods had a clear seasonal succession and compositions differed in Kuroshio and nearshore waters. *Temora turbinata* (Dana, 1849) was recorded in the northwestern part of Kueishan Island with high density of aggregation and an abundance of 17255.15 individuals/m^3. The dominant species during all three monsoonal periods were *Calanus sinicus* Brodsky, 1962 (relative abundance: 33.47), *T. turbinata* (RA: 55.66%), and *Paracalanus parvus parvus* Tanaka, 1956 (RA: 15.14%). Since *C. sinicus* is an indicator species for the China Coastal Current (CCC), it reflects that species from northwest waters of East China Sea can be transported to the investigated waters via CCC. Copepod abundance was significantly higher during Southwest monsoon than in the other two monsoonal periods ($p < 0.01$, one-way ANOVA). On the contrary, number of species, indices of richness and diversity of copepods were significantly lower during the southwest monsoon than during the other two periods ($p < 0.05$, one-way ANOVA). Overall, the interplay between the CCC and Kuroshio water affects the composition of planktonic copepods in the investigated area.

S18-17300 Oral (ECOP)

Zooplankton assemblages associated with submarine canyons off the east coast of South Africa.

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Submarine canyons are steep-walled valleys that incise continental margins. Increasing evidence suggests these canyon environments are biodiversity hotspots and essential nodes for stimulating productivity in surrounding shelf areas. Zooplankton biomass, abundance, and diversity were compared between three canyons (Wright, Diepgat and Leven) and adjacent non-canyon areas off the northeast coast of South Africa in 2018 and 2019 to explore the role of submarine canyons in the pelagic zone. We found no consistent canyon effect on zooplankton biomass, abundance, or species composition, however, these metrics varied with sampling location and year. Zooplankton biomass was highest at Leven Canyon (16.68 $mg.m^{-3}$) in 2018, but in 2019 it was highest at Leven non-canyon (12.85 $mg.m^{-3}$). Biomass was lowest at Wright non-canyon in both years. Zooplankton abundance was highest at Diepgat non-canyon in 2018 (350.56 $ind.m^{-3}$) but was highest at Diepgat Canyon (244.60 $ind.m^{-3}$) in 2019. Like biomass, the abundance was lowest at Wright non-canyon in both years. The zooplankton community was highly diverse, with 87 taxa identified in 2018 and 84 taxa in 2019, 70% of which were copepods. Small copepods such as *Oncaea* spp., *Paracalanus* spp., and *Temora* spp. were dominant in all locations. Future long-term studies with a high sampling frequency of zooplankton, currents and environmental variables can assist in obtaining a more detailed view of the influence of these canyons.

S18-17313 Oral

Enhanced nitrogen regeneration by planktonic copepods in the oligotrophic subtropical ocean under active N_2 fixation

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Zooplankton-mediated food-web linkages underlie the highly efficient nutrient recycling that sustains high levels of phytoplankton productivity in the oligotrophic open oceans. However, the details of the metabolic response in relation to the environmental gradients in the vast subtropical waters are not understood well due to methodological constraints. In this study, we adopted a highly sensitive analytical method to compare the geographical variation of ammonium and phosphate excretion rates in *Pleuromamma xiphias* in the tropical/subtropical North Pacific (0–20°N). Phosphorous excretion of female *P. xiphias* collected from the surface at night was rather constant, ranging from 0.04 to 0.23 µgP/mgDW/h, negatively correlated with its body weight. Whereas ammonium excretion had much wider variability (0.14–1.19 µgP/mgDW/h), resulting in a wide range of atomic N:P ratio (1.1–16.1) in regenerated nutrients. The ammonium excretion rates exhibited a significant negative relationship with the body $\delta^{15}N$ as well as POM $\delta^{15}N$, suggesting that individuals in the waters under higher nitrogen fixation activity regenerated much more nitrogen than those in the oligotrophic water without nitrogen fixation. Since the trophic positions and genetic clades were different among the populations in the habitat with/without nitrogen fixation, geographical variation in trophic adaptation could be attributable to the characteristics of ammonium excretion. The results imply that the role of planktonic copepods in nutrient regeneration, particularly in terms of nitrogen, is variable in the oligotrophic open water.

S18-17335 Oral (ECOP)

Unraveling past population events in Southern Ocean diatoms: using population genomics in demographic inferences

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The productivity in the Southern Ocean is primarily driven by the abundance of phytoplanktonic species. Temporal changes in the biomass of plankton are often measured using sediment records but provide limited resources to assess changes at the population-level. Population genomic methods hold the potential to shed light on speciation events as well as intraspecific changes in abundance of plankton. Inferring intraspecific demographic histories at lower trophic levels is fraught with difficulties due to complex life-history traits that make estimations of key parameters, such as mutation rates and generation time, challenging. We employed genomic data to infer the demographic history of the diatom *Fragilariopsis kerguelensis* in order to assess the impact of past climate changes. We detected three distinct genotypes among 47 strains sampled along a latitudinal transect. All genotypes appear to be sympatric along the Polar Front, with no signs of introgression. We detected two major changes in abundance during the last 100,000 years in two of the three genotypes. The detected demographic bottlenecks were placed in periods during the Pleistocene that were subject to large scale environmental changes. The methods and analyses presented here can serve as a blueprint for similar studies in zooplankton with which we can gain a deeper understanding of the effective population sizes, demographic history, and adaptive responses at the lower trophic levels in our ocean; the basis of most marine ecosystems.

S18-17408 Oral

Growth rates and biomass concentration - What determines large-scale zooplankton productivity pattern? Conclusions from a comprehensive study in the North Atlantic

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Background: ICES-WG of Zooplankton Ecology worked comprehensively to determine North Atlantic mesozooplankton net-production using 26 time series from subtropical to subpolar regions with different trophic states. Results were compared with satellite born climatological sea surface temperature and chlorophyll values, two factors which determine body mass of organisms living in the buoyancy field. Derived empirical equations allowed calculation of productivity at the same high spatial resolution and climatological scale as the remote sensing data themselves, valid on average for the layer from which the plankton samples were taken.

In this context, an appropriate equation of growth rate calculation was selected from more than seventy options. Decision based on the comparison of all calculated growth rates and productivity indicators like the ratio of potential oxygen consumption and nitrogen excretion, calibrated against enzymatic growth activity, measured during the ICES/GLOBEC sea-going workshop at Storfjorden in June 1993. Together with P/B-ratios from the literature it gave a "decision window" which included seven equations. The equation finally chosen covers a wide range of invertebrates and body masses.

Net production requires biomass concentration and growth rates as input variables. We confirmed the opinion that biomass variability is significantly more important than growth rates except at low concentrations.

S18-17413 Oral (ECOP)

Effects of salinity, temperature, microalgal diet and stocking density on the production of two paracalanid copepods

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Captive breeding techniques for marine ornamental fish have been receiving increasing attention in recent years, both for conservation purposes and due to the demand in the aquarium market. However, a significant challenge in marine ornamental larviculture remains the high mortality rate during the larval first feeding stage. This is primarily attributed to their extremely small mouth gap, and underscores the importance of producing micro-sized zooplankton as live prey. This research aims to establish pure mono-species culture strains and mass culture technologies for two micro-sized paracalanid copepods (*Bestiolina* sp. and *Parvocalanus* sp.) isolated from coastal waters of Taiwan. The study evaluates the effects of temperature, salinity, algal diet, and stocking density on their life cycle (including development time for each stage and life span) and productivity (egg production and population growth). Additionally, the fatty acid compositions of the two species are analyzed. The results indicate that both copepod species have small-sized nauplii (70-90 µm), short life cycles (6-7 days), high tolerance to high culture density (1-9 ind./mL), great nutritional value (eicosapentaenoic acid: 5% and docosahexanoic acid: 10%), and exhibit slow swimming behavior. These findings suggest that *Bestiolina* sp. and *Parvocalanus* sp. hold great potential as live prey for the feeding of small-mouth fish larvae.

S18-17416 Oral (ECOP)

Co-cultures of macroalgae *Chaetomorpha* sp. and two marine zooplankton, harpacticoid copepod *Tisbe* sp. and rotifer *Brachionus rotundiformis*

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Copepods and rotifers are crucial live feeds for the aquatic larvae in the aquaculture industry. The co-culture of macroalgae with marine organisms is an emerging concept in marine farming, which could provide several advantages, such as stabilizing water quality and increasing habitat space, to enhance the overall productivity of farmed animals. This study aims to investigate the effects of macroalgae *Chaetomorpha* sp. co-culture on the production of two marine zooplankton, harpacticoid copepod *Tisbe* sp. and rotifer *Brachionus rotundiformis.* In the experiment of *Tisbe* sp., the copepods were cultivated under three different treatments: (1) control; (2) 3 g (117.3 cm^2) of *Chaetomorpha* sp.; (3) 6 g (234.6 cm^2) of *Chaetomorpha* sp. The highest production rate was recorded in the control treatment, with nauplii (N) and copepodite+adult (C+A) population growth rates reaching 715.6 ± 40.6 ind./day and 210.4 ± 35.1 ind./day, respectively. The co-cultures of higher quantities of *Chaetomorpha* sp. led to the decline of population growth rate in *Tisbe* sp. production. In the *Brachionus rotundiformis* experiment, rotifers were cultivated under three different treatments: (1) control; (2) 3g of *Chaetomorpha* sp.; (3) water extract of *Chaetomorpha* sp. After 4 days of cultivation, the highest density was observed in the control treatment (96.5 ind./ml), while the lowest density was found in the water extract treatment (56 ind./ml). Our findings suggest that the macroalgae *Chaetomorpha* sp. is not suitable for co-culturing with the harpacticoid copepod *Tisbe* sp. and rotifer *Brachionus rotundiformis*

S18-17430 Oral

Broadband acoustics as a tool to better understand the composition of mesopelagic layers

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Determining the composition of the diverse communities responsible for oceanic sub-surface and mesopelagic scattering layers is challenging. Multiple techniques are required to understand their composition and dynamics better. In recent years, improvements in acoustic broadband instrumentation have shown the potential to complement more traditional sampling methods (i.e., nets and optics). Typically, acoustic work on scattering layers has been limited to lower frequencies (i.e., 18 and 38 kHz) in narrowband mode because these are effective at sampling the top 1000m of the water column and because these systems are readily available on research and commercial vessels. As broadband systems become available at low frequencies, it is essential to investigate further how they can enable us to identify the composition of these layers, partition the acoustic data based on acoustic properties, and improve our interpretation of the acoustic observations. More detailed information about the composition of scattering layers will also support more specific targeted physical sampling. Here, we looked at acoustic data acquired from 12 to 200 kHz in three regions (the western South Pacific, the sub-Antarctic sector of the Southern Ocean, and the Ross Sea) to compare frequency responses from various layers and schools with scattering models applicable for different taxa based on their acoustic properties (i.e., fluid-filled, gas-filled, and elastic bodies). We also explored using the scattering models to predict information on organisms' size distribution. This approach could lead to improved information on species composition of scattering layers, species distribution and accuracy of biomass estimations for certain taxa.

S18-17716 Oral (ECOP)

Comparative metatranscriptomics uncovers the physiological responses of zooplankton to environmental heterogeneity.

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Zooplankton plays a crucial role in coastal water ecosystems by linking energy transfer from primary producers to higher trophic level organisms and facilitating the biogeochemical cycle through their metabolism and vertical migration. However, our understanding of the zooplankton response to environmental heterogeneity, particularly at the gene expression level, remains limited. This knowledge gap hinders our understanding of their physiological processes, which are essential for the biogeochemical cycle. To investigate the impact of coastal environmental parameter heterogeneity on zooplankton community diversity and physiology, we conducted spatial and vertical zooplankton samplings during the summer season in the western, southern, and eastern Coastal Hong Kong Waters. Metatranscriptomics analysis was employed to unravel the community composition and gene expression profiles of the sampled zooplankton. Our findings reveal a pattern of differential gene expression associated with nutrient (nitrogen and phosphate) biosynthesis and oxygen metabolism related functions. These gene expression patterns corresponded to the observed heterogeneity in Nitrogen:Phosphate ratios and dissolved oxygen levels within their living environment. Our results contribute to a better understanding of zooplankton's physiological processes, especially the importance of incorporating gene expression when studying zooplankton's role in the biogeochemical cycle.

S18-17007 Poster (ECOP)

The abundance and distribution of mesozooplankton communities on the Mozambique shelf

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Mesozooplankton constitute a key component of marine ecosystems, playing a vital role in the food web, transferring organic energy to higher trophic levels, and their abundance and distribution provide fundamental information on the ecosystem dynamic, functioning and productivity, important to identify and manage potential fishing stocks, and biodiversity hotspots. Previous studies based on satellite chlorophyll-a suggested that the most productive areas in the Mozambique shelf are Angoche, Sofala Bank and Delagoa Bight. The correlation between such satellite derived high chlorophyll-a, mesozooplankton distribution, and abundance has not yet been detailed along the Mozambique shelf, and is lacking. This study aims to examine the patterns of mesozooplankton distribution, abundance, biomass and community structure along the Mozambique Shelf, from two surveys in 2017 and 2018 (SA Agulhas II and Dr. Fridtjof Nansen, respectively), and correlate with the main environmental factors to investigate the role of these factors play in shaping the observed distribution patterns. Preliminary results shows that in 2017, the mean mesozooplankton biovolume over the Sofala Bank (between Beira and Angoche) was 0.19 ml/m3 , ranging from 0.04 to 0.95 ml/m3 . The Zambezi delta has the highest mesozooplankton concentrations to the south (0.95 ml/m3) and north (0.82 ml/m3 , in water depths of <50m. The southern maximum was associated with a region of relatively warm (26.4°C) and fresh (34.9 PSU) water presumably related to river outflow. The biomass was greatest close to the shore in the southern area of the Sofala Bank off the Zambezi River mouth, presumably related to the river plume, with low biomass observed offshore.

S18-17071 Poster

Effects of hypoxia on benthic eggs of calanoid copepods in the Southern Sea of Korea

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Global warming is affecting the composition, structure, and function of marine ecosystems. The increase in hypoxic regions due to stratification is a major environmental problem worldwide. Off the southern coast of Korea, hypoxia occurs frequently in summer, and the area of water affected is gradually expanding. In this study, we investigated the effects of hypoxia on the eggs of copepods in the order Calanoida. Data on the distribution and abundance of eggs in benthic sediments were collected from 17 stations, using a piston core sampler (64 mm internal diameter, 50 cm length), from August 1 to 7, 2012. Significant variations in the distribution of calanoid eggs and the occurrence of abnormalities in egg development were found between stations. The abundance of eggs found in the sediments ranged from 0.004 to 2.389 × 106 eggs·m−2 , with higher abundances identified in hypoxic than in normoxic areas. The proportion of abnormal eggs ranged from 0 to 92.7%. In particular, there were significantly more abnormal than normal eggs in areas where hypoxia occurred ($p < 0.01$). These results show that hypoxia can have a lethal effect on calanoid eggs and further affect population and community dynamics.

S18-17100 Poster

Iron fertilization can enhance the mass production of copepod, *Pseudodiaptomus annandalei*, for fish aquaculture

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Copepods are proven nutritious food sources for the mariculture/larviculture industry, however, unreliable methods for mass production of copepods are a major bottleneck. In this study, we modified a previously reported inorganic fertilization method (N: 700 μg L^{-1} and P: 100 μg L^{-1}) by the addition of iron (Fe: 10 μg L^{-1}, using $FeSO_4{\cdot}7H_2O$) (+Fe treatment) and compared its suitability for copepod culture (*Pseudodiaptomus annandalei*) to the original method (control). The experiment was conducted outdoors in 1000 L tanks for 15 days. The addition of iron prolonged the growth phase of the phytoplankton and resulted in the production of significantly more small phytoplankton (0.45–20 μm, average 2.01 ± 0.52 μg L^{-1} vs. 9.03 ± 4.17 μg L^{-1} in control and +Fe, respectively) and adult copepods (control: 195 ± 35 ind L^{-1}, +Fe: 431 ± 109 ind L^{-1}), whereas copepodid-stage was similar between treatments (control: 511 ± 107 ind L^{-1} vs. +Fe: 502 ± 68 ind L^{-1}). Although adding iron increased the cost of production by 23% compared to the control, the estimated net profit was 97% greater. We concluded that inorganic fertilization, with the addition of iron (Fe: 10 μg L^{-1}), could be an effective method for the mass production of copepods for larviculture.

S18-17106 Poster (ECOP) CANCELLED

~~**Investigating zooplankton in contrasting coastal ecosystems along India's east coast**~~

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~~This study investigates the diversity and distribution of zooplankton in three contrasting ecosystems of the western Bay of Bengal: the estuary (Mahanadi), lagoon (Chilika), and coastal waters (off Gopalpur). Over two years (Y1:2017-2018; Y2:2018-2019), field surveys were conducted seasonally during the monsoon (MON), post-monsoon (POM), and pre-monsoon (PRM). The study identified 15 taxonomic groups, including meroplankton. In Y1, estuary had highest diversity (113), followed by coastal waters (81) and lagoon (56). In Y2, coastal waters led (98), followed by estuary (79) and lagoon (49). Dominant zooplankton groups included copepoda, cladocera, malacostraca, ciliophora, and meroplankton. Population sizes varied seasonally. In coastal waters during Y1, PRM had the highest density, then MON, and POM. In Y2, PRM also had the highest density, followed by POM and MON. Similar trends occurred in the estuary and lagoon. Copepoda consistently dominated in terms of species richness and density in coastal waters across all seasons in both years. In the lagoon, meroplankton thrived during MON and POM, whereas malacostraca dominated PRM in Y1. In Y2, MON saw continued meroplankton abundance, but copepoda took over in POM and PRM. In estuary, MON witnessed more meroplankton and cladocera in Y1 and Y2, respectively, with copepoda dominating in POM and PRM across both years. *Chydorus sphaericus* indicated eutrophic conditions during the monsoon, while *Belzebub hanseni* signified influx of marine species due to tides in both lagoon and estuary environments during post-monsoon and pre-monsoon periods. Seasonal and spatial variations, alongside dominant species, offer critical insights into the intricate coastal relationships.~~

S18-17164 Poster

Egg dormancy in the perennial copepod *Acartia hudsonica* in a northern temperate bay

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Egg dormancy is a key life history trait in calanoid copepods living in estuarine and neritic habitats with large environmental variability. The production of resting eggs has predominantly been observed in species or populations that seasonally disappear from the water column. However, we found that *Acartia hudsonica* produces resting eggs in Otsuchi Bay, northeastern Japan, where this copepod occurs year-round. To clarify the role of resting eggs in their population dynamics, seasonal abundance, egg production, and hatching of *A. hudsonica* were investigated for two years in the bay. Adults and copepodites of *A. hudsonica* were present throughout the year, with high abundance in winter-spring and lower summer-fall densities. Females produced resting eggs from spring to summer (April–July) and in winter (January-February). During these periods, 7–57% of individual females laid subitaneous and resting eggs simultaneously. Resting eggs of *A. hudsonica* hatched gradually over an extended period (20–90 d) at *in situ* temperatures (8–20°C). The hatching time varied greatly between individual eggs even within a clutch. A high hatching success (>90%) of resting eggs was found regardless of incubation temperature, indicating no special temperature requirement for the termination of dormancy. Our results suggest that *A. hudsonica* does not strongly rely on the resting eggs to persist in Otsuchi Bay. Instead, the simultaneous production of two physiologically different eggs by females and delayed and asynchronous hatching of the resting eggs may function as a bet-hedging strategy to cope with unpredictable adverse conditions.

S18-17250 Poster (ECOP)

Assessing changes in the size of *Scomber scombrus* and *Trachurus trachurus* spawning stocks in the NE Atlantic and North Sea through ichthyoplankton sampling in the international MEGS survey series

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The triennial international horse mackerel and mackerel egg survey series (MEGS) incorporates ichthyoplankton sampling to assess the size of the spawning stock of Northeast Atlantic mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*). The survey started in 1977 and has since expanded to encompass a broad spatial and temporal coverage of the northeast Atlantic, including the North Sea. Sampling is carried out using high-speed plankton samplers (GULF-VII and Nakthai) with the intention of estimating the abundance and production of stage 1 eggs of mackerel and horse mackerel.

We present results from ichthyoplankton samples obtained by Cefas in the North Sea portion of the Mackerel Egg Survey from 2022 and illustrate how these data can be used to determine the distribution and size of the spawning stock which spawns in the North Sea. We also compare the 2022 survey results with surveys in previous years. The survey design consists of transects at 0.5^{o} latitude spacing and sampling stations at 0.5^{o} longitude spacing. Fish eggs were sorted from the samples, imaged and processed using ImageJ software. Adult mackerel were also sampled, in this case using rod and line, from which fecundity estimations were obtained to convert egg productions into estimates of the adult fish spawning stock biomass. The resulting distributions of stage 1 eggs show how Atlantic mackerel and horse mackerel spawning distributions can be derived from ichthyoplankton sampling. We also discuss the potential influence of environmental variables on relatively fine scale variability in distributions.

S18-17255 Poster (ECOP)

A snapshot of ichthyoneustonic assemblage off North-West Africa

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Despite inhabiting the easily accessible surface of the ocean, the neuston community has been only poorly studied, particularly with a focus on fish larvae and eggs. Here, we present the first data on the ichthyoneuston assemblage along the Canary Current Large Marine Ecosystem (CCLME). Sampling took place in October-November 2019 covering the northern west African coast (11°N-35°N). Neuston samples were collected at 58 stations positioned in transects perpendicular to the coast, using a manta net (mesh size: 335 µm). Sorted fish larvae were identified to the lowest possible taxonomic level using both morphological approaches and DNA – barcoding (cytochrome c oxidase subunit I). A total of 6210 fish larvae were identified, representing 35 families and 31 species. The early life stages of epipelagic fishes consisted more than 50% of the total fish abundance, dominated by the larvae of small pelagic fish (mainly sardines, anchovies and carangids). Larvae of the order Beloniformes i.e., sauries (Scomberesocidae), halfbeak (Hemiramphidae) and flying fishes (Exocoetidae), were also found to be an important component in the manta collections. Our data showed an increase in abundance values towards the southern part of the study area, as well as a latitudinal difference in species composition. The observed distribution patterns, composition, and diversity of ichthyoneuston assemblage are discussed in relation to the oceanographic conditions in the CCLME, contributing to a deeper understanding of this relatively understudied ecological niche in the study area.

S18-17297 Poster (ECOP)

Crisis at depth: vertical distribution of calcifying plankton along a shallowing aragonite saturation horizon

Robin L. **van Dijk**[1,2], A. Daniëlle van der Burg[1,3], Giada Spagliardi[2], Geert-Jan Brummer[4], Anne Kruijt[5], Ben Cala[4,5], Olivier Sulpis[6], Matthew P. Humphreys[4], and Katja T.C.A Peijnenburg[1,3]

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Calcifying plankton play a critical role in the biological carbon pump by facilitating organic carbon export to the deep ocean. Ocean acidification, driven by rising atmospheric CO_2 concentrations, poses a significant threat to planktonic calcifiers by increasing the solubility of calcium carbonate ($CaCO_3$), making it harder to form and maintain shells. While temperature has been identified as the primary driver of the distribution of calcifiers, the effects of ocean chemistry, particularly changes in saturation states, remain less explored. Given the predicted shallowing of $CaCO_3$ saturation horizons, it is important to understand the effects on the distribution of calcifying plankton, encompassing both calcite producers (e.g., foraminifera and coccolithophores) and aragonite producers (e.g., pteropods, heteropods, and janthinids), both horizontally and vertically in the water column. Here, we use morphological and metabarcoding approaches to examine the diversity and abundance of planktonic calcifiers from depth-stratified multinet samples along a 4000 km meridional transect in the South Atlantic Ocean. Alongside the multinet samples, measurements of oxygen and carbonate system parameters (pH, DIC, and total alkalinity) were made that offer a better understanding of how the observed spatial shallowing of the aragonite saturation horizon is influencing abundance and diversity in the South Atlantic Ocean. We use a combination of universal and taxon-specific primers and a custom-made reference library for planktonic calcifiers to maximise taxonomic resolution and minimise false negatives. Our findings shed light on the potential repercussions of changing ocean chemistry for the distribution of production and dissolution of $CaCO_3$ in open ocean systems.

S18-17312 Poster

Plastic responses to warming and nitrogen availability in a subtropical copepod *Pseudodiaptomus annandalei*

Xuejia **He**, Zhixian Pan, Baoye An, Gaoming Xu, and Ziyu Wang

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Global warming and anthropogenic activity may cause thermal stress and nutrient limitation to zooplankton, but the phenotypic plasticity of copepod under the effects of warming and nitrogen (N) availability is unknow so far. A common subtropical and trophical copepod *Pseudodiaptomus annandalei* was exposed to 20, 25, 30 ^{o}C and high, medium, and low dietary nitrogen conditions in a full factorial design to test two hypotheses:1) do increasing temperature and dietary N content interact on ingestion, growth, development and reproduction? 2) is there correlation and trade-off between plastic responses? Clearance rate, ingestion rate and somatic growth rate increased significantly with the increasing temperature. The slowest copepodite development occurred in the 20 ^{o}C/low dietary N (29.9±3.7 d) treatment, whereas the fastest one in the 30 ^{o}C/high dietary N (9.5±1.2 d) treatment. The 30 ^{o}C/medium dietary N treatment had the highest survival rate (46.5%), and the 20 ^{o}C/high dietary N treatment had the lowest. It is suggested that increasing temperature improved greatly copepodite development, increased survival rate, and partially set off the detrimental effects of dietary nitrogen deficiency. Increasing temperature enhanced reproduction of copepod with the highest egg production rate, hatching rate, and normal offspring rate in the 30 ^{o}C/high dietary N treatment than other treatments, but the dietary N deficiency partially set off the positive effects of increasing temperature. Trait-specific interactions between effects of temperature and dietary N content on physiology and life-history of *P. annandalei* were suggested in this study.

S18-17315 Poster (ECOP)

Dynamics and causes of trophic cascades induced by mesozooplankton in a warm drainage area of Dayawan Bay, northern South China Sea

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Some mesozooplankton have a selective preference for feeding on microzooplankton. Omnivorous and carnivorous mesozooplankton can reduce the feeding pressure of microzooplankton on phytoplankton, thereby promoting the growth rate of phytoplankton and generating trophic cascades. Dayawan Bay is a semi-enclosed bay in the north of the South China Sea. It is rich in biological resources and diverse in habitats. The establishment of the Dayawan Bay Nuclear Power Plant has led to an increase in the water temperature of the surrounding sea area due to its thermal discharge, which has brought environmental changes to organisms. Studies on the impact of thermal drainage from nuclear power plants on zooplankton focuse on species composition, biomass, and biodiversity of zooplankton communities. There is limited research on the top-down effects of zooplankton feeding on food communities. The warm drainage area of the Dayawan Bay Nuclear Power Plant and its surrounding waters have natural temperature gradients. This study took this area as the experimental site to conduct seasonal on-site cultivation experiments (mesozooplankton feeding experiments and microzooplankton dilution experiments). Based on the experimental results, the feeding rate and trophic cascade of mesozooplankton on lower trophic plankton were calculated. The impact of various environmental factors (especially temperature) on the dynamic changes of trophic cascades was analyzed through generalized additive model. This study will explain the mechanism of the regulation of low trophic level biological communities by the feeding of mesozooplankton in the study area, and clarify the role of mesozooplankton groups in stabilizing planktonic ecosystems.

S18-17318 Poster (ECOP)

Effect of prey selectivity and trophic cascades induced by mesozooplankton on the dynamics of phytoplankton

Mianrun **Chen**[1], Yueyue Si[2,3], Liuyu Han[4], Xin Liu[3], Bangqin Huang[3] and Chang-Keun Kang[5]

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This presentation will reveal our results conducted in the Pearl River estuary (PRE), Southern China that mesozooplankton had diverse effects on different size fractions and taxonomic groups of phytoplankton via a combination of strong feeding selectivity and trophic cascades. High ingestion rates by mesozooplankton suppressed the accumulation of microphytoplankton(>20 μm), whereas low ingestion rates by mesozooplankton and resultant trophic cascades promoted the biomass of nano-sized (2−20 μm) and pico-sized (0.7−2 μm) phytoplankton. Among phytoplankton groups, diatoms were passively selected by mesozooplankton despite their high concentrations in natural seawater, whereas dinoflagellates and cryptophytes were actively preferred by mesozooplankton in spring and autumn. Similarly, ciliates were also preferred by mesozooplankton despite their lower biomass compared to phytoplankton, which induced a trophic cascade that indirectly increased the biomass of smaller phytoplankton. The overall feeding effect of mesozooplankton on phytoplankton was determined by the balance between direct grazing rates and indirect compensation with trophic cascades. The degrees of carnivory of the mesozooplankton, which determined the strength of trophic cascades, varied among seasons, resulting in weak control of algal blooms by mesozooplankton. Our findings provide insights into the complex trophic interactions between mesozooplankton and other plankton groups in dynamic natural ecosystems.

S18-17383 Poster

Developing products to aid taxonomic consistency and rigour in plankton microscopy

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We have continuously collected phytoplankton and zooplankton in Australian waters for the past 15 years as part of the Integrated Marine Observing System (IMOS). We run two plankton observing programs: the National Reference Stations and the Australian Continuous Plankton Recorder Survey. Plankton time series in Australian waters was traditionally limited to local areas and short durations, with no plankton observing program lasting longer than three years historically. This limited the plankton taxonomic research and information available. Over the past 15 years, we have developed a suite of taxonomic products that has improved our plankton identification by microscopy over time and bolstered our data quality control and consistency across our two laboratories and eight analysts. This ensures that our data – which are continuously uploaded to the Australian Ocean Data Network where it is publicly available for free download – are reliable and robust, allowing long-term and large-scale analyses and comparisons. The taxonomic products we have developed include Species Identification Sheets, Genus and Family Summary Sheets, interactive LUCID Identification and Diagnostic Keys, Image Databases and Range Mapping. We have made these resources freely available to other plankton identification laboratories globally.

S18-17384 Poster **CANCEL NOT CONFIRMED**

~~Zooplankton Biogeography in Brazilian Estuaries~~

~~Felipe **Gusmão**, Mariana de Souza Rodrigues~~

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~~The Brazilian coastline spans approximately 9,200 km and is characterized by a rich diversity of features resulting from variations in climate, oceanography, and geological formations. One remarkable aspect of the entire Brazilian coast is the presence of 41 large estuaries, varying in size from 40 km^2 to 10,000 km^2. These estuaries exhibit significant differences in their structure and functioning, which can be attributed to the diverse oceanographic, climatic, and geological characteristics of their respective regions. These highly diverse estuarine characteristics are closely associated with unique ecosystem features and diverse species assemblages, often linked to marine ecoregions or biogeographic provinces. Understanding how these ecosystems function and the biogeography of Brazilian estuarine biodiversity is essential for the conservation of these environments. Evidence suggests that the biogeography of certain estuarine groups, such as benthic organisms and fish, differs somewhat from adjacent marine ecoregions. In our study, we compiled the first dataset of estuarine zooplankton in Brazil, comprising data from 30 estuaries collected from various sources, including published studies, theses, dissertations, and reports. Through this analysis, we identified five ecoregions based on estuarine zooplankton data: North, Northeast-North, Northeast-South, Southeast, and South. These regions exhibited distinct assemblages of species, with the greatest diversity and taxonomic distinction found in the South. The ecoregions defined by estuarine zooplankton assemblages displayed alignment with marine ecoregions but also showed similarities with inland biogeographical regions. This result suggests that estuarine zooplankton biogeography can be influenced by both marine and inland or river basin characteristics.~~

S18-17389 POSTER (ECOP)

Difference in the vertical distribution of mesozooplankton in the western Indian Ocean

Hyeon Kim[1,2], Minju Kim[1,2], Dong-Jin Kang[2,3], and Jung-Hoon **Kang**[1,2]

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We investigated the difference of vertical distribution of zooplankton community at two stations (A and B) characterized by Seychelles-Chagos Thermocline Ridge (SCTR) in the western Indian Ocean (WIO) in 2023. Zooplankton was collected at five depth strata from surface to 1,000 m with MultiNet (200-μm mesh, 1-m^2 mouth-size) every 6h over 24h. Total mesozooplankton abundance was higher at station A corresponding to upwelling zone (2,214±1,309 inds./m^3) than station B with no upwelling (1,123±199 inds./m^3). The mesozooplankton abundance remained high in surface mixed layer (SML) (1,488±941 inds./m^3) for 24h at station A, whereas the abundance was high in thermocline (571±137 inds./m^3) except dawn at station B. Most zooplankton occurred higher in SML and thermocline at station A associated with high chlorophyll-*a* compared to station B. Mesozooplankton have mostly remained in SML and thermocline, while a few mesozooplankton remained constantly below thermocline at both stations. Radiolarians and *Paracalanus parvus* s.l. were numerically dominant in SML, and radiolarians and *Pyrocystis noctilua* dominated in thermocline at station A, while *P. noctilua* and radiolarians were common in SML and thermocline at station B. Most zooplankton did not exhibit diel vertical migration (DVM), whereas some mesozooplankton (>2 mm) showed normal DVM (*Pleuromamma abdominalis, Scaphocalanus echinatus* and *Aidanosagitta neglecta*) at both stations. At night, most DVM species ascended to SML at station A, whereas the DVM species ascended to thermocline at station B. These results suggested that SCTR affected variation in the vertical distribution of DVM species as well as total mesozooplankton in WIO during the study.

S18-17580 Poster (ECOP) -CANCELLED

~~**The influence of hydrological and environmental conditions on zooplankton diversity in the Bydgoszcz Canal and in the Noteć Canal (Poland)**~~

~~Nikola **Kolarova** and Paweł Napiórkowski Kazimierz~~

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~~The hydrobiology of canals in Europe has been sparsely investigated. Therefore, I was motivated to study the hydrological and environmental factors which cause zooplankton diversity in Bydgoszcz Canal and the Noteć Canal. The first goal of my research was the assessment of zooplankton variability depending on the locations of the designated sites. The Bydgoszcz Canal sites showed the greatest diversity, abundance and biomass of zooplankton compared to sites in the Brda River or the Noteć Canal. I also tried to determine the impact of human activity on quality of water in canals. I assessed trophic state changes based on zooplankton indicators - rotifers (TSIROT) and an indicator based on Secchi disk visibility (TSISD) in artificial, slow-flowing and stagnant canal waters. The indices calculated on the basis of qualitative and quantitative data of rotifers correlated with the TSISD index. According to obtained results the rotifers seem to be an important indicator of trophic state in canals. The next goal was to determine how hydrotechnical structures can affect the zooplankton of the canal. I assessed the variability of environmental conditions and zooplankton upstream and downstream of the locks. Based on the statistical analysis, environmental and biological conditions differed between habitats located upstream and downstream of locks. The canals seem to be an attractive place to live for zooplankton organisms and conducted research provides new data about these artificial ecosystems.~~

~~S18-17609 Poster (ECOP)~~ **CANCELLED**

~~Plankton growth and respiration under multiple stressors~~

~~Andriana **Koutsandrea**[1,2], Anna Törnroos-Remes[2], Katja Anttila[3], Tytti Maria Uurasmaa[3], Sanna Sihvo[4], Andrew House[4], Minna Holopainen[4] and Jonna Engström-Öst[1]~~

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~~The long-chained polyunsaturated fatty acids (PUFA) affect the quality of plankton as food and are critical for organism's reproduction, growth, and survival and are thus considered one of the main drivers of ecosystem health and stability. Recent work shows that the PUFA in microalgae are projected to reduce up to 30% in future oceans due to global warming. This is alarming and can have devastating consequences across the pelagic and benthic food webs. With sub-optimal prey available, the consumers are forced to feed more intensively to obtain sufficient PUFA, and to reduce the risk of developmental delays. This study aims to monitor PUFA, respiration/growth potential and the biomarkers of pelagic organisms along the coastal zone in different environmental conditions. Measuring growth and respiration are one of the most important variables when the environment is changing rapidly, as they provide information about the condition, health and well-being of measured individuals. Also, other biomarkers can be measured, such as oxidative stress and antioxidants. The samples were collected from 4 different areas in the Baltic Sea (the open sea, shallow waters, anoxic and eutrophicated environments), between June and September. The results will be discussed in the meeting.~~

S18-17723 Poster (ECOP)

Innovative subset representation: reducing labelling efforts in plankton image classification with metadata

Mojtaba **Masoudi**[1], Sarah L.C. Giering[1], Jean-Olivier Irisson[2], Miquel Massot-Campos[3], Noushin Eftekhari[4], and Blair Thornton[3]

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The traditional approach to plankton image classification relies heavily on time-consuming and expensive labelled data annotation for fully-supervised learning. In light of the escalating volume of unlabeled data annually, it becomes imperative to investigate methodologies that alleviate the labelling burden. This paper introduces a novel approach to semi-supervised plankton image recognition, leveraging self-supervised learning to eliminate the need for extensive labeled data. Our multi-stage framework focuses on the effective representation of image subsets using metadata information, thereby significantly reducing the labelling efforts required for plankton image classification. Unlike conventional methods that categorize subsets based on their classes, our approach prioritizes learning balanced individual subset views for downstream tasks. Experimental results on UVP6 camera data showcase the high effectiveness of our framework in identifying 10 plankton species within a severely imbalanced dataset, where the detritus class dominates the samples. Additionally, our strategy, incorporating a multi-view approach and harnessing depth and location metadata information, substantially improves accuracy in plankton image classification.

Workshop 1: Reference sequence databases for global zooplankton biodiversity: Optimization, applications and user guidelines

Convenors:
Silke Laakmann (Germany), Corresponding
Ashrenee Govender (South Africa)
Jenny Huggett (South Africa)
Todd O´Brien (USA)
Leonie Suter (Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water)

Speakers:
Iole Di Capua (Stazione Zoologica Anton Dohrn, Italy)
Junya Hirai (Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Japan)
Jennifer Questel (College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks AK, USA)

Molecular genetic approaches are used with increasing frequency to detect, discriminate, and identify species of marine zooplankton, and to characterize diversity of marine ecosystems. We have progressed rapidly from using DNA barcodes to identify single specimens, to DNA metabarcoding to characterize the diversity of environmental samples and communities. In both cases, the assignment of a sequence to a species, or classification to a taxonomic group, requires an accurate and complete reference database of DNA sequences based upon morphologically identified specimens. Currently, zooplankton sequence data can be found in several databases, which differ in their submission process, associated metadata, availability of sequence data (local vs. open access) and taxonomic groups represented. In addition, there is a variety of available algorithms to assign the sequences to diverse taxonomic ranks.

This workshop covers topics such as: overviews on sequence data for diverse ocean regions and taxonomic groups; improving coverage and completeness of local, regional, and global sequence databases; priorities for continuing efforts toward both geographical and taxonomic coverage and reliable assignment of species and taxonomic groups; and, a topic of increasing importance, how to handle zooplankton and environmental DNA metabarcoding data in databases and analyses to reliably identify zooplankton communities.

The aim of this workshop is to engage researchers working on taxonomic groups across pelagic communities in diverse marine ecosystems to exchange information and advice, share their experiences, and discuss next steps toward the ultimate goal of reliable identification of species, analysis of biodiversity, and patterns of connectivity among ecosystems based on sequence data.

The workshop will include presentations on the design, maintenance, and use of DNA reference databases for zooplankton. Discussion sessions and breakout groups will focus on the selection of genes and gene regions, sequencing technologies and platforms, bioinformatics pipelines, and inter-comparison and inter-calibration of the results for local-to-global characterization of marine zooplankton diversity.

W01-17152 Invited (ECOP)

Efforts on DNA barcoding deep-sea zooplankton from the Gulf of Alaska, North Pacific Ocean

Jennifer **Questel**[1], Caitlin Smoot[1], Allen Collins[2,3], Dhugal Lindsay[4] and Russell Hopcroft[1]

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The majority of DNA barcodes for zooplankton from the North Pacific Ocean come from collections obtained from the epipelagic and mesopelagic zones. However, zooplankton species that reside in the deep ocean still lack barcodes for commonly used genetic markers. We report on substantial barcoding efforts across major zooplankton taxonomic groups collected from surface waters to the rarely sampled abyssopelagic zone (0 – 4,500 m) from the Gulf of Alaska, North Pacific Ocean. Over 1,200 specimens were identified from which mitochondrial (16S and COI) and nuclear (18S) genetic markers were sequenced. In total, ~4,000 sequences for over 250 unique taxa were generated for these 3 markers, of which ~400 sequences represent new contributions for species previously lacking DNA barcodes. In addition to traditional barcode sequencing, we report on results from genome skimming (low-coverage whole genome sequencing; Illumina HiSeq platform) for “ultrabarcodes” (complete, or near complete, mitochondrial genomes and ribosomal repeat units) for select taxa. As environmental sequencing (i.e., metabarcoding, metagenetics, and eDNA) becomes an increasingly favorable and informative tool for numerous applications in marine ecosystem studies, results are often hindered by incomplete reference DNA sequence databases. Thus, DNA barcodes from this work are being incorporated into the MetaZooGene Atlas and Database (https://metazoogene.org), an open-access data and metadata portal for barcoding genes used for classifying and identifying marine organisms.

W01-17362 Invited (ECOP)

Reference sequence data for marine zooplankton in the era of high-throughput sequencing

Junya **Hirai**

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Zooplankton have high diversity in the global oceans, and a molecular-based method helps identify zooplankton, including cryptic species and immature stages. However, reference sequence data obtained by DNA barcoding are available for limited numbers of zooplankton species or locations in the global oceans. Only a small amount of DNA can be obtained from tiny zooplankton, and the high diversity of zooplankton frequently causes a primer mismatch during PCR amplification. A conventional method of DNA barcoding can provide only short sequences of a target gene. On the other hand, high-throughput sequencing (HTS) is a promising technology to efficiently obtain reference sequence data of zooplankton. For example, genome skimming or transcriptome approaches need no species-specific PCR primers, and we can assemble target regions such as mitogenome and nuclear rRNA sequences from massive sequence reads produced by HTS. These sequences can be used for phylogenetic analysis, designing group-specific primers, and species identification of zooplankton using a long-sequencing technology in the future. Metabarcoding data using HST are also good reference data for zooplankton distributions. For example, metabarcoding data of COI are now increasing for zooplankton in the global oceans, and distributions of new species can be investigated based on sequence similarity in the available metabarcoding data. In the presentation, my ongoing projects for zooplankton diversity are introduced, and the advantages and limitations of using HTS can be discussed to obtain reference sequences of zooplankton in the global oceans.

W01-17407 Invited

Integrating α taxonomy and DNA barcoding for enhanced zooplankton characterization: insights from the Gulf of Naples

Iole **Di Capua**

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Advances in zooplankton species identification have been revolutionized by DNA sequencing, offering a robust framework for accurate species determination. This study employs an integrated approach, merging α taxonomy and DNA barcoding, to characterize key taxa within the zooplankton community inhabiting the Gulf of Naples at the Long-Term Ecological Research site Marechiara (LTER-MC), situated in the Central Tyrrhenian Sea of the Western Mediterranean. Attention is being focused on selected copepod, cladoceran, euphasiid and sergestid species, chosen for their ecological significance in this area. Notably, this investigation contributes newly validated reference sequences from the Mediterranean Sea. These sequences underpin the creation of a comprehensive, region-specific database, to boost the knowledge of the real zooplankton biodiversity, which can be often underestimated using phenotypic approaches only. Moreover, our ongoing investigation provides new high-quality molecular references of the analysed zooplankton taxa, and contributes to unveil the genetic diversity of zooplankton species and their relevant ecological significance for Mediterranean coastal areas.

W01-17103 Oral

Reference COI Barcode Database for Euphausiids: Progress, Prospects and Promise for Understanding Biodiversity, Biogeography and Demographic History

Ann **Bucklin**[1], Paola G. Batta-Lona[1], Jennifer M. Questel[2], Vickie You[1], Richard Antosca[1], Peter H. Wiebe[3]

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Euphausiids are key links in marine food webs and are essential for ecosystem function and sustainability throughout the world ocean. Many euphausiid species have extensive biogeographical distributions spanning multiple ocean basins, creating the possibility of population genetic differentiation and cryptic speciation. Analysis of the DNA barcode region of mitochondrial cytochrome oxidase I (COI) has been used to identify and discriminate euphausiid species and examine geographic patterns of genetic diversity and structure, trace pathways of population connectivity, and infer demographic history. We provide a global overview of COI barcoding of euphausiids based on the MetaZooGene Atlas and Database (MZGdb; https://metazoogene.org/database), which now includes ~3,000 barcodes for 64 of 83 accepted species, with 19 accepted species with no barcodes. Analysis of COI sequences focuses on species of two genera, *Stylocheiron* and *Thysanoessa*, to examine the taxonomic, ecological, and evolutionary significance of geographic variation within and between species. These studies demonstrate the need for representative COI barcodes for identified specimens collected across the geographic range of each species. Remaining challenges and opportunities are described to encourage work toward a taxonomically- and geographically-complete reference database for COI barcodes for euphausiids across the global ocean.

W01-17139 Oral

Assessing barcoding completeness by taxonomic group and ocean region using the MetaZooGene Atlas and Database (MZGdb)

Todd D. **O'Brien** and MetaZooGene (SCOR WG157) members

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Molecular methods (including DNA barcoding and metabarcoding) are powerful tools for studying zooplankton diversity at multiple levels: populations, species and communities. For all molecular applications, especially environmental DNA (eDNA), taxonomically complete and geographically comprehensive reference databases, including multiple gene regions used to discriminate different taxonomic groups or levels, are essential. While millions of sequences exist in the publicly available archives and databases, many marine zooplankton species are missing and overall coverage is far from complete. Current barcoding completeness varies by taxonomic group and ocean region, based on cross-referencing NCBI GenBank with species reported in OBIS and COPEPOD,. The best coverage is generally found in commercially important groups (e.g., fish, squid, and decapods) and in the larger-sized zooplankton (e.g., euphausiids, ctenophores, pteropods). Even in regions with relatively high completeness levels, e.g., North Atlantic, most taxonomic groups have <30% of accepted species sequenced.

There are several key questions that can be used to guide and prioritize efforts toward comprehensive reference databases for marine zooplankton. These include: which species are found in a region, how many of these species have been barcoded, and which taxonomic groups show lowest levels of completeness? The MetaZooGene Barcode Atlas and Database (MZGdb, https://metazoogene.org/mzgdb) is designed to enable and facilitate these goals, providing new tools, including coverage maps and data tables, to summarize and analyze the status of publicly-available barcode data for marine species by taxonomic group and geographic region across the global ocean.

W01-17184 Oral (ECOP)

Evaluation of zooplankton biodiversity in two critical coastal ecosystems in the Province of Aklan, Philippines using DNA metabarcoding: estuary versus coral reef

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Coastal areas are home to diverse ecosystems such as estuaries, mangrove swamps, seagrass beds, coral reefs and adjacent pelagic environment, which support the highest biodiversity of species. The Plankton are the foundation of the world's aquatic ecosystems. It encompasses almost if not all living things on earth, from the microscopic organisms, such as viruses, microbes, unicellular plants or phytoplankton, animals or zooplankton, and to the various life stages of larger organisms with high economic values, including corals, invertebrates and vertebrates. They play a crucial role in the maintenance of the overall well-being of our aquatic ecosystems. However, biodiversity decline has accelerated to an unprecedented rate caused by the deterioration of ecosystems. This calls for an urgent need to accelerate species discovery and inventory, assess biodiversity, identify threatened ecosystems and establish efforts for mitigation and protection. This study is part of a global effort (SCOR Working Group MetaZooGene) to accelerate documentation and or inventory of various species using integrative morphological-molecular approaches. Here, we present zooplankton biodiversity from two critical ecosystems in Batan (estuary) and Tangalan (coral reef) Bays, Aklan, Philippines, revealed through metabarcoding of the cytochrome oxidase I (COI) and 18S rRNA genes. Notable results include species composition of both holoplankton and meroplankton showing close affinity to the ecosystem. Mollusks (gastropods and bivalves) and decapods appeared prominent in Batan, for which the Bay is famous in the Philippines, whereas Tangalan showed a relatively high occurrence of cnidarians. Unassigned sequences observed range from 5-6% or ~over 6000 sequences were unrecognizable.

Workshop 2: Today I Learned: Useful tools and data resources that every researcher should know

Convenors:
Todd O´Brien (USA), Corresponding
Claire Davies (Australia)

Today I learned ("TIL") is a reference to the Reddit online thread where people share newly discovered ideas and information with the broader community. At symposiums like ZPS7, people also learn about new tools and data resources (as well as the science) during the various presentations. Imagine discovering a new tool or data resource that can literally save you weeks or months of work?! Then imagine missing that talk because you were in a different concurrent session! This interactive workshop is an opportunity for the community to introduce and share their favorite tools and data, from GitHub to R libraries, from new databases and data compilations to online tools and visualization resources. In addition to hosting traditional presentations and posters, this half day workshop will also feature speed talks and an online discovery board with summaries and links to a variety of tools and data resources (provided by the ZPS7 community) that can make a researcher's life easier. At a minimum, this workshop will include new products from multiple ICES zooplankton-focused working groups (a biometric/traits database, a molecular database) and COPEPOD's spatio-temporal expansion to its time series toolkit.

W02-17196 Poster

The Biological Ocean Observer: An online portal for the visualisation of IMOS data

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Access to online marine data streams has never been easier, however the number of files and range of formatting creates complexities around data download, integration and visualisation. Not everyone has the necessary skills to make use of the data resources available. Here we demonstrate a solution to simplify these processes for all users: the *Biological Ocean Observer* (BOO). BOO is an online Shiny application that Integrates, Analyses and Visualises IMOS data so that everyone can better understand, query and interpret it. BOO increases our ability to deliver impact by expanding the analysis and visualisation of biological data to a broad audience and accelerating the generation of scientific insights. BOO uses internationally recognised programming frameworks (R and Shiny), and all code are freely available, facilitating further development and collaboration with the community. The Shiny application is underpinned by an R-package (*planktonr*) that allows power-users to replicate the data and visualisations they access from BOO, but also to modify the analysis and visualisation for their use case. This tool is designed to be used by a wide range of national stakeholders including science researchers, natural resource managers, policy makers, educators and the general public – including you!

W02-17367 Poster

The WGZE InfoHub: An online portal for sharing links to data, tools, and other useful resources for plankton and ecosystems research

Todd D. **O'Brien**

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The Zooplankton Production Symposium is one of my absolute favorite meetings, with every session and workshop about the little floating critters that I love. Even better, every day I learn about new plankton-related data sets, software, tools and other online resources that were previously unknown to me. Sadly, the challenge with concurrent sessions and workshops is that we cannot be in three places at once. What if we missed an exciting new tool or resource just because it was being presented a different room?

Workshop W2 ("Today I learned: Useful tools and data resources that every researcher should know") was created to allow people to share information about the tools, data, and other resources that they have created or that they use to do their research. To help W2 with information sharing, the ICES Working Group on Zooplankton Ecology (WGZE) has created an InfoHub web portal where the W2 links and information can be shared before, during, and after the symposium. Even if you cannot attend one of the W2 workshop events, new information will continue to be added to the InfoHub page throughout the symposium:

https://wgze.net/infohub

Do you have something you wish to share? The WGZE InfoHub has a simple online submission form where you can enter and share information about a data/tool/resource that you use in your own work. Your InfoHub submission might save someone else days/weeks/months of effort, or introduce them to something completely new.

Workshop 3: Global plankton time series synthesis and comparisons

Convenors:
Julie Keister (USA), Corresponding
Jennifer Fisher (USA)
Priscilla Licandro (Italy)
Anthony Richardson (Australia)
Samantha Zeman (USA)

Speakers:
Todd O'Brien (NOAA Fisheries, USA, COPEPOD Project Leader)

Plankton time series offer invaluable lower trophic ecosystem information on local or regional scales that cumulatively can inform us of global ecosystem response to climate change. Comparisons and contrasts across regions can amplify our understanding of climate impacts beyond that gleaned from individual datasets, particularly where local time series are relatively short. We propose a workshop that assembles scientists and data from international plankton time series to elucidate unifying intra- and inter-annual patterns, with a strong focus on the response of plankton species composition and abundance to climate perturbations, such as heatwaves. We aim to bring together varied phyto- zoo- and ichthyoplankton datasets to 1) discuss common and novel statistical methods for elucidating trends, 2) share and disseminate existing analytical methods (and code if applicable), and 3) compare and contrast disparate datasets to evaluate responses to global climate change. To meet these goals, we propose a mix of short scientific talks focused on plankton patterns, trends, and time series analysis techniques; large group discussions centered on time series goals and expectations; and small breakout groups focused on data analysis and comparisons. Bringing together international plankton programs will raise awareness of global monitoring efforts and could offer novel global perspectives to address unifying questions. The objective of this the workshop would be global synchrony, but with tangible goals of initiating regional comparisons. We envision participants would be involved in, or have interest in, ocean monitoring programs and ideally would come to the workshop with datasets and overarching questions in mind. The ultimate goal of the workshop would be to outline major questions that our combined datasets could address, and to conduct initial analyses that demonstrate proof of concept to address them.

W03-17130 Invited

A 20-year history of plankton time series compilation and comparison efforts: Lessons learned and techniques developed

Todd D. **O'Brien**[1] on behalf of WGZE[2]/WGPME[3]/WG125[4]/WG137[5]/IGMETS[6]

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[3]ICES Working Group on Phytoplankton and Microbial Ecology
[4]SCOR WG125 - Global comparisons of zooplankton time series
[5]SCOR WG137 - Global patterns of phytoplankton dynamics in coastal ecosystems
[6]IOC/UNESCO International Group for Marine Ecological Time Series

At the 3rd International Zooplankton Production Symposium (Gijón, Spain, 2003), inspiration from a workshop lead to the formation of a new SCOR working group: Global comparisons of zooplankton time series (WG125). Complimentary and expanded plankton time series working groups and studies continued on-and-off over the next 20 years, first looking at phytoplankton (WGPME, WG137), then expanding the scope of variables to include temperature, salinity, nutrients, pigments, and all plankton (WGZE/WGPME, IGMETS). The time series in these compilations differed widely in years of sampling (*e.g.*, 10-50+ years), protocols and equipment used (*e.g.*, net types, mesh sizes, sampling depths), sampling frequency (*e.g.*, monthly, weekly, one season only), and taxonomic resolution (*e.g.*, from undifferentiated bulk "total catch biomass" to species-level abundances). A variety analyses were applied by the working groups. The simplest analyses were more inclusive and robust enough to handle shorter, sparser data time series with occasional gaps or breaks. The more advanced analyses were usually more restrictive, working best with near-monthly sampling and at least 20 years of data. Among these efforts common results emerged: local hydrographic conditions (*e.g.*, upwelling, coastal currents or river run-off) can obscure climate trends; obtaining time series data from some countries and programs proved difficult or impossible; certain ocean regions have little or no available time series (*e.g.*, South Pacific, Indian Ocean). This talk summarizes the work of five large-scale time series comparison efforts and highlights some of the methods, visualizations, and tools achieved as a result.

W03-17163 Oral

Comparison of the response of copepods to interannual change across three regions of the North Pacific

Julie E. **Keister**[1,2] and David G. Kimmel[1]

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[2]University of Washington School of Oceanography, Seattle, WA, USA

We compare time series of total copepod biomass and abundances of two contrasting species of copepod from three regions of the North Pacific - the Bering Sea (2005-present), Gulf of Alaska (1994-present), and southern Salish Sea (2014-present) - across years of large environmental variability including marine heatwaves. The copepod species examined were the large-bodied, warm-water copepod *Calanus pacificus,* and the smaller, cold-water species *Acartia longiremis.* To compare data collected by different monitoring programs with different protocols, temporal, and spatial resolution, the data were summarized into annual z-scores to explore responses to environmental change among regions. Here we will introduce these publicly-available time series datasets and show similarities and differences in the time series that highlight regional differences in response to climate events and differential responses among species.

W03-17272 Oral

Intra- and cross-basins comparison of zooplankton time series to further investigate observed changes in Mediterranean coastal communities

Ehsan Vesal[1], Patrizia Borrello[2], Roberta De Angelis[2], Alessandra De Olazabal[3], Marina Giallain[4], Alenka Goruppi[3,5], Sarah Magozzi[4], Maria G. Mazzocchi[1], Valentina Tirelli[3,5], Paolo Vassallo[4,5], Paolo Povero[4,5], Maila Severini[2], Emanuela Spada[2] and Priscilla **Licandro**[1,5]

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Recent findings have highlighted significant changes in coastal zooplankton at a long-term monitoring station in the Gulf of Naples (LTER-Marechiara site, Tyrrhenian Sea, Western Mediterranean). In particular, after 2010 a relative increase of crustacean and gelatinous filter feeders (cladocerans, appendicularians and thaliaceans) and overall decrease of copepods, have been observed. Such change coincided with a relative decrease of neritic copepod species and an increase of copepod taxa typically living in offshore epi-mesopelagic waters. This suggests an enhanced influence of offshore waters at the LTER-MC site, possibly associated with climate-driven hydrological shifts.

In order to test this hypothesis and verify whether changes occurred in Naples are confirmed at a broader geographical scale, an intra- and cross-basin comparison of zooplankton coastal communities will be conducted using data from three long-term monitoring stations available in the Western Mediterranean (LTER-Marechiara in the Tyrrhenian Sea and LTER-Portofino in the Ligurian Sea) and in the Adriatic Sea (Gulf of Trieste Time series). The obtained results will be further verified using zooplankton time series made available within the national marine monitoring program over a relatively short period (2015-2021), in eight geographical sub-regions located across the Italian coast.

W03-17306 Oral (ECOP)

Empirical dynamic modeling to understand zooplankton time series amid climate change

John A. **Conroy**[1], Megan Cimino[1], Jarrod A. Santora[2], Deborah K. Steinberg[3] and Stephan Munch[2]

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Long-term warming and many nonlinear interactions shape biophysical responses of ocean ecosystems, and we strive to understand these systems despite incomplete information. Empirical dynamic modeling (EDM) is a nonparametric approach that uses temporal lags to account for unobserved variables and to infer time-series dynamics (e.g., autocorrelation and periodicity). Time series must be sufficiently long (often >30 years, perhaps shorter for some zooplankton) to capture species' dynamics. We share our experience applying EDM to understand 6-year recruitment cycles of Antarctic krill over three decades. Our case study demonstrates how EDM is becoming accessible to a broader group of researchers analyzing plankton time series. Algorithms can accommodate multiple site-specific time series if a program samples different geographic locations, which may allow diagnosis of spatio-temporal variability with fewer years of data. Specifying size classes and including environmental covariates also allows assessment of intrinsic vs. extrinsic drivers underlying population change. The statistical analysis is executable using a documented R package. In addition to this case study, we are prepared to share our approach for merging species density data from two long-term zooplankton time-series programs spanning 1992-2023 along the western and northern Antarctic Peninsula. We considered taxonomic resolution, size information, tow depth, and sampling date during data screening, then adjusted nighttime density to account for diel vertical migration. We expect these data processing and statistical modeling approaches will be useful for other scientists working to understand zooplankton time series amid climate change.

W03-17319 Oral (ECOP)

Patterns, processes, and challenges maintaining a high frequency multi-decadal time series of hydrographic and plankton observations off Newport, Oregon, USA

Jennifer L. Fisher[1], Samantha M. **Zeman**[2], Kym Jacobson[1] and Anna Bolm[2]

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Scientists working on the Newport Hydrographic Line (NHL) off Newport, OR, USA have been monitoring ocean conditions and plankton communities in the Northern California Current twice monthly to monthly, year-round, for 26 years. These data have been key to understanding the connectivity between changes in ocean-climate and ecosystem structure and function. Sampling along the NH Line occurs at 7 stations from 2 - 46 kilometers from shore. Routine measurements include 1) vertical profiles of temperature, salinity, oxygen, and fluorescence, 2) surface water samples for nutrient, chlorophyll, and phytoplankton species composition, and 3) zooplankton with a ½ m diameter plankton net (200 µm mesh) and 60 cm Bongo nets (333 µm mesh). This long time series spans several “natural experiments”structured by environmental and climate variability, which has allowed the detection of climate-ecosystem correlations at seasonal, and inter-annual to decadal time scales. We will discuss some of the patterns we have observed, how the data are used in fisheries management, and some of the challenges in maintaining and analyzing high-frequency, multi-decadal time series.

W03-17368 Oral

Seasonal variation of mesozooplankton community structure around Japan, western North Pacific Ocean

Kazuaki **Tadokoro**

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The waters around Japan consist of subtropical and subarctic waters within a narrow latitude band, which forms diverse marine environments. Since the distribution of zooplankton is greatly influenced by the marine environment, a diverse community structure is expected to be formed in the waters around Japan. The Studies have been conducted in many waters around Japan. However, few studies have been conducted on the seasonal changes in community structure based on simultaneous surveys. In this study, seasonal variation was examined using zooplankton samples collected in simultaneous surveys conducted by the Japan Fisheries Research and Education Agency and the prefectural fisheries research institute. The zooplankton communities were classified into four groups through cluster analysis. Group 1 is the cold water community, mainly comprising cold-species. Group 2 represents the transition community, consisting of both cold and warm species. While both Group 3 and Group 4 are considered warm water communities, Group 3 exhibits a higher abundance of neritic species. Clear seasonal shifts in the zooplankton communities were observed in the waters around Japan. In the Oyashio waters, Group 1 predominated from winter to summer, followed by Group 2 in autumn. In the Kuroshio waters, Group 3 was dominant from winter to spring, while Group 4 prevailed from summer to autumn. In the Sea of Japan, Group 3 mainly appeared from winter to summer in the southern part, while the northern part exhibited a prevalence of Group 2.

W03-17391 Oral

Exploring the mechanisms causing the long-term change in plankton across the NE Atlantic and NW European shelf

Angus **Atkinson**[1], Amanda Beesley[1], Mike Best[2], Stefano Corona[3], Matthew Holland[4], Margarita Machairopoulou[5], Dafne Eerkes-Medrano[5], Andrea J. McEvoy[1], Abigail McQuatters Gollop[4], Clare Ostle[6], Katrin Schmidt[4], Timothy J. Smyth[1], Karen Tait[1], Glen A. Tarran[1], Claire E. Widdicombe[1] and E. Malcolm S. Woodward[1]

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The NE Atlantic and NW European shelves have warmed rapidly over the last 40 years and have seen widespread increases in meroplankton and summer declines in microplankton and key holoplankton groups. This represents a decline in the “classical food chain” from diatoms to copepods to fish larvae. Climatic warming has also been associated with increasing frequency of extreme weather events such as storms and marine heatwaves, but the effects of these on plankton are less well understood. This contribution shows how we are using a great network of time series in this area to explore the response of zooplankton to both direct and indirect effects of increasing temperature, and at scales ranging from those of weather extremes (weeks) to multidecadal cycles. We are taking a dual, size- and taxonomically-based approach, with the latter examining the feeding traits (e.g. fine filter feeding, using a feeding current, carnivory) that could make specific taxa winners or losers under both climatic extremes and secular change. We are examining a series of alternative hypotheses, for example: that warming has direct effects by shifting the range, phenology or size of zooplankton; that warming has indirect bottom-up affects, for example by increasing summer stratification, reducing nutrient supply and reducing phytoplankton abundance and dominant cell size; and that the taxa increasing during and after summer marine heatwaves are also winners under long-term warming. By examining the degree of support for these various hypotheses, we can better understand the mechanisms behind the profound changes that are being observed.

W03-17411 Oral

An overview of Canada's plankton monitoring programs and time series in coastal British Columbia, Canada

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Multiple plankton time series are maintained by Fisheries and Oceans Canada (DFO) in coastal and offshore systems within (and adjoining) Canada's Pacific EEZ. Here we provide an overview of our current time series with a focus on two long-term monitoring programs: the Salish Sea plankton monitoring program; and the West Coast of Vancouver Island (WCVI) plankton time series. In addition to standard physical and chemical oceanographic measurements, both programs employ similar methods for sampling zooplankton and phytoplankton. Plankton sampling by DFO in the Salish Sea started in 1996 with varying temporal effort in Haro, Juan de Fuca, and Georgia straits. Sampling since 2015 has been more routine, sampling on a biweekly to monthly basis and includes spatially resolved taxonomy and biomass measurements for both phytoplankton (microscopy and pigments) and zooplankton (microscopy). Nearly identical measurements have been used for the WCVI time series. Sampling along the outer coast began in 1979 along the southern Vancouver Island shelf, slope, and offshore. The survey area was expanded to include northern Vancouver Island and Queen Charlotte Strait in the early 1990's. Monitoring interannual change of the biomass and abundance of climate-ocean indicators and lower-trophic level productivity are key objectives of both programs. However, we also note that differences in oceanography translate to different species-groupings used as climate/productivity indicators for each time series.

Workshop 4: Zooplankton morphological identification. Is it still necessary?

Convenors:
Antonina dos Santos (Portugal), Corresponding
Lidia Yebra (Spain)

Speakers:
Tony Miskiewicz (Ichthyology Department, Australian Museum Research Institute, Sydney, Australia)
Julian Uribe-Palomino (CSIRO, Australia)

Plankton is at the base of the marine food web and it supports important fisheries worldwide. The taxonomic identification of plankton (morphological and/or integrative) is key and the starting point for any subsequent field and experimental ecological research. The range distribution of species is changing due to introduction by ballast waters and poleward expansions driven by global warming because of climate change. A correct identification of plankton species, including non-allochthonous ones, is very relevant for Integrative Ecosystem Approaches and in relation to the assessment of the marine environmental status. On the other hand, integration of molecular information into the species identification process is significantly enhancing the tools available for species determination. Given the relevance of the taxonomic assignment of species, ICES launched a new series of the ICES Identification Plankton Leaflets which provides up-to-date and correct information for the identification of zooplankton species for ecological and biodiversity studies. Struggling with the availability of taxonomic experts in several key zooplankton groups our intention with this workshop is to bring attention and discuss the importance of taxonomy and morphology of plankton for the science that it is been done today. In this forum, we aim to gather insights from a wide range of zooplankton taxa, and to foster an international network of experts.

W04-17714 Invited

Beyond the microscope, ink and Paper: The importance of integrated taxonomy for planktonic microcrustaceans identification.

Julian **Uribe-Palomino**

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Morphology is at the core of traditional taxonomy, and it is still the base for description of most eukaryotic species however, this morphological approach that has been used for more than 3 centuries has shown limitations that have been revealed by reproductive and larval development experiments and the application of molecular techniques such as DNA barcoding in the modern era. This is not different for the zooplankton. This diverse community consisting of around 35 groups, many of those meroplanktonic, whose morphology change dramatically as the metamorphose to adults. Effective identification of sub-adult specimens is often difficult or not possible when they do not exhibit the morphological features required for a proper species ID of their corresponding adults. We will discuss the validity of morphology as the main tool for species identification along the ontogeny of zooplankton microcrustaceans and how molecular and cutting-edge techniques contribute to this process without necessarily becoming the alternatives to define a species but be a complement to the species description and furthermore, clarifying the evolutionary relationships among species.

W04-17715 Invited

Review and assessment of traditional and new methods for identification and descriptions of development of fish larvae

Anthony G. **Miskiewicz**

Ichthyology Department, Australian Museum Research Institute, Sydney, Australia. E-mail: tonymisk@yahoo.com

For many fish species, morphology and pigment patterns can change dramatically from newly hatched larvae through larval development to the juvenile stage. As a result, identification of fish larvae in plankton samples to species requires detailed descriptions of larval developmental series for different species. The traditional method for identifying and describing the larval development of fish species is to assemble a developmental size series based on larval morphology, pigmentation, myomere number and head spine patterns, with the largest specimens in the series identified to species using adult characters. More recently, several innovative techniques such as DNA barcoding of ethanol and formalin fixed samples using the COI gene, metabarcoding and micro-CT scanning have been used to assist in the identification of fish eggs and larvae, especially for speciose groups where adult characters such as meristic counts or coloration are of limited used for identification for larvae of different species.

I will briefly review the traditional methods for identification of fish larvae and the status of larval fish identification in Australia. I will then discuss examples of the application of new techniques such as COI barcoding, metabarcoding and micro-CT scanning and how they can complement and assist in identification of fish larvae. Finally, I will discuss broader issues related to the future of larval fish identification.

W04-17722 Oral

Zooplankton morphological identification. Is it still necessary?

Antonina **dos Santos** and Lidia Yebra

I. P. M. A., Portugal. E-mail: antonina@ipma.pt

Morphological taxonomy is at the core of all knowledge on marine zooplankton. Without species morphological identification it was not possible to study species ecology and biology. Therefore, taxonomy and systematics constitute the scientific basis for the study and classification of biodiversity, depending on the morphological description of species and diagnostic identification keys. Therefore, the ICES Plankton Leaflets, launched in 1939, were for several decades the primary guides to identify zooplankton species in the North Atlantic and worldwide. The morphological identification of plankton is a time-consuming activity that requires knowledge and expertise. With the development of molecular techniques, allowing metabarcoding of bulk samples and/or the eDNA analysis of filtered water without the original individuals, much of this work has been abandoned and most of the experts on certain zooplankton groups are now retired or no longer available. However, both techniques (morphological taxonomy and molecular analysis) can often underestimate or overestimate biodiversity, a problem that can be exacerbated by the enormous number of undescribed species and the non-indigenous species colonizing new areas. For this reason, an integrative taxonomic approach has been developed where different DNA molecular markers improve taxonomic knowledge. Is this already taking place in a large scale to monitor marine ecosystems? Is there still a need for morphological taxonomy? How can we construct and curate the DNA libraries without morphological knowledge on the species?

Workshop 5: Approaches towards findable, accessible, interoperable and reusable (FAIR) zooplankton trait data as stepping stones to improved functional ecology

Convenors:
Kieran Murphy (ARC Australian Centre for Excellence in Antarctic Science,University of Tasmania, Australia) (Corresponding)
Brian Hunt (University of British Columbia (UBC), Canada)
Patrick Pata (University of British Columbia (UBC), Canada)
Jessica Titocci (National Research Council (CNR), Research Institute for Terrestrial Ecosystems (IRET), Lecce, Italy, Lecce, Italy)

Speakers:
Jason Everett
((1) School of the Environment, The University of Queensland, St Lucia, Australia; (2) Centre for Marine Science and Innovation, University of New South Wales, Sydney, Australia; (3) CSIRO Environment, St Lucia, Australia)
Ilaria Rosati
(National Research Council (CNR), Research Institute on Terrestrial Ecosystems (IRET), Lecce, Italy)

Zooplankton organisms are a fundamental component of marine ecosystems where they play a wide array of ecological roles, reflected by their diverse functional traits. In the attempt to capture and deeply understand these ecological roles, trait-based approaches and trait datasets have increased globally. Nonetheless, the lack of common standards and guidelines for acquiring, organizing and describing zooplankton trait data largely limits their findability, accessibility, interoperability and reusability (FAIR). The application of FAIR principles will unite trait-based research through the use of common standards and practices and advance trait-based approaches in zooplankton research by promoting further innovation, especially in mechanistically linking organismal-level traits to ecosystem-level functioning.

The objectives of the workshop are to review the current status and future perspectives of zooplankton trait-based research and its ecological applications, and discuss the challenges of applying FAIR principles and analyzing zooplankton trait data, through a series of talks and open discussions. We therefore welcome submissions for presentations related to: (1) zooplankton functional ecology, (2) trait data collection and management, and (3) novel frameworks and analytical methods in trait-based studies. Presentations will be followed by hands-on sessions that will introduce digital services and semantic resources developed to improve zooplankton functional trait-data harmonization and interoperability (e.g., Zooplankton Trait Thesaurus), and present an example of a global zooplankton trait database and assemble a species-traits matrix from it. The participants are invited to collaborate in a discussion regarding the strategies and challenges in advancing zooplankton trait-based research and outline a road map for zooplankton trait data sharing, data management, and ecological applications.

W05-17727 Invited

Adopting FAIR and open science practices for zooplankton trait data

Ilaria **Rosati** and Jessica

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Biodiversity data, including functional diversity data, are increasingly made openly available, facilitated by extensive digital infrastructures that support data standardization and publication. Open sharing of data is crucial for enhancing the reproducibility of research, reusing data in new research applications, minimizing the duplication of research effort, and, last but not least, ensuring researchers receive credit for their efforts. Recently, with the universal acceptance of data sharing's importance for advancing research, best practices, such as the FAIR data principles, have been developed to guide this process. These principles outline four key attributes of effectively shared data: findable, accessible, interoperable, and reusable. While these principles have been well developed for primary biodiversity data, challenges persist in sharing trait data. This talk aims to provide best practices and a roadmap for adopting FAIR and open science practices in the domain of zooplankton trait-based approaches.