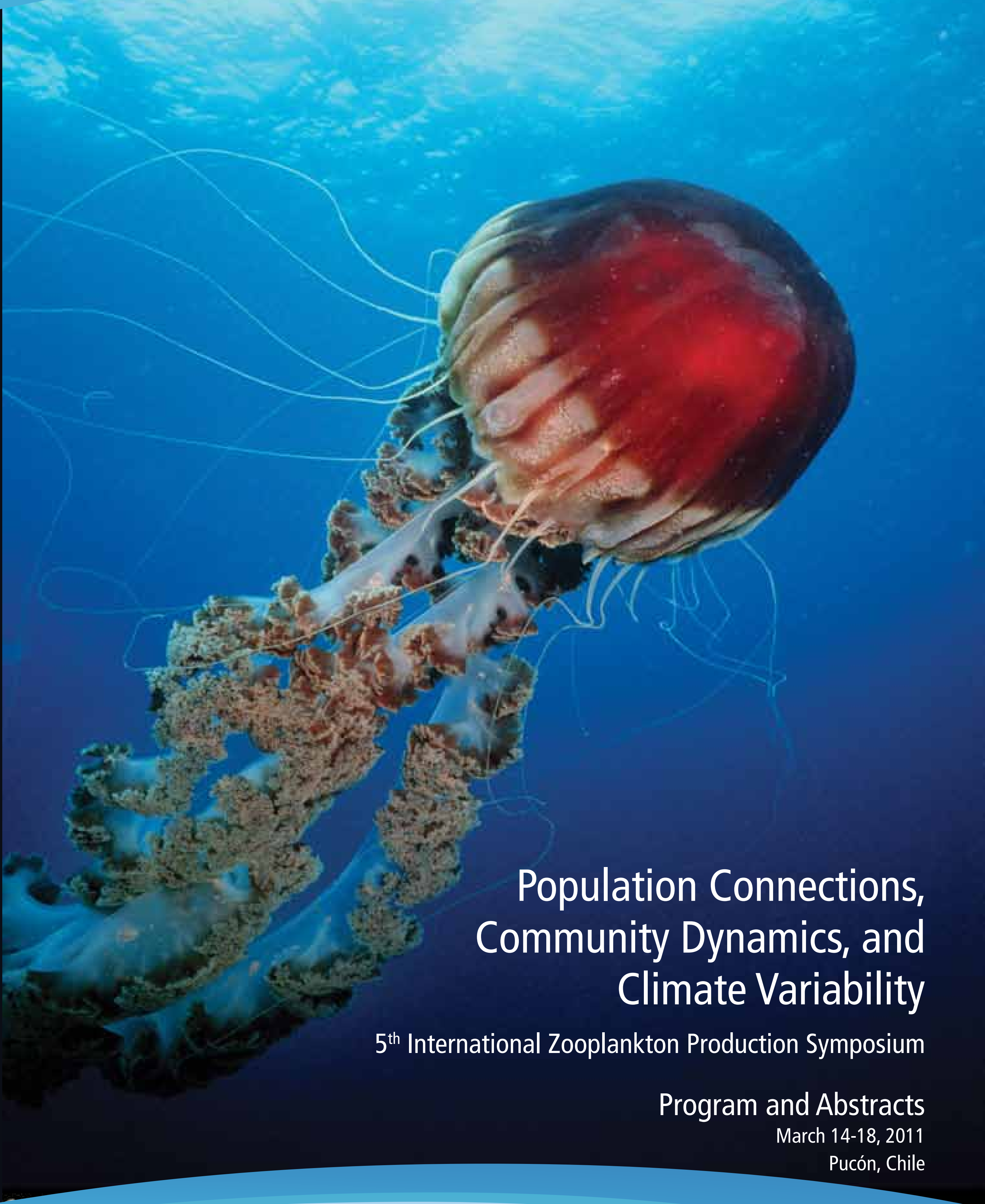

Population Connections, Community Dynamics, and Climate Variability

5th International Zooplankton Production Symposium

Program and Abstracts

March 14-18, 2011

Pucón, Chile

5th International Zooplankton Production Symposium

Population Connections, Community Dynamics, and Climate Variability

March 14 – 18, 2011
Pucón, Chile

Table of Contents

Abstracts for oral presentations are sorted first by date and then by presentation time. Abstracts for posters are sorted by session and then by paper ID number. Presenter name is in bold-face type and underlined. Some abstracts in this collection are not edited and are printed in the condition they were received.

Welcome

On behalf of the symposium conveners, organizers, and scientific steering committee, we welcome you to beautiful Pucón, a city of many natural wonders. Here along the shores of Lake Villarrica and at the foot of the live Volcano Villarrica, we join together close to 400 scientists from 40 countries to share our knowledge of and excitement in the study of zooplankton. The theme of this symposium "*Population Connections, Community Dynamics, and Climate Variability*" encompasses a wide diversity of studies that are sure to enlighten us. Ten sessions and five workshops will address the state of our knowledge on how climate change will impact zooplankton populations, the roles of zooplankton in diverse ecosystems, their importance in food webs and carbon cycling, and much more. We look forward to the many excellent presentations and encourage all participants to take advantage of this unique opportunity to exchange experiences and ideas with fellow zooplanktologists from around the world.

We would like to thank PICES, ICES, and the numerous people who have worked over the past three years to bring this symposium together. The symposium was made possible only through the hard work of the local and international organizers, professionals at the PICES Secretariat, your participation, and the generous financial support from our sponsors. Without those efforts and funds, it would have been impossible to convene a symposium of such broad scope. The hard work will continue after the symposium to assemble some of the best papers presented here in a special issue of the ICES *Journal of Marine Science*.

Pucón is one of the most popular tourist cities in Chile because of the abundant local opportunities to enjoy the natural wonders of the country. *We expect that* you will use the *symposium* as an excuse to explore the region with your family, friends, and colleagues, and hope that you will have a productive, stimulating, and enjoyable meeting, the memories of which are warm and lasting.

Ruben Escribano
Symposium Convenor and Chair of the Local Organizing Committee

Julie Keister
Symposium Convenor

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Symposium Timetable

<table>
<tr><td colspan="6">Monday, March 14</td></tr>
<tr><td>08:30
12:30</td><td colspan="5">OPENING SESSION
Plenary
Salon Pucon (Salones Araucania + Lonquimay)</td></tr>
<tr><td>14:00
18:00</td><td colspan="2">Theme Session S3
(Salon Araucania)</td><td colspan="3">Theme Session S6
(Salon Lonquimay)</td></tr>
<tr><td>18:30
21:00</td><td colspan="5">Welcome Reception
(Ballroom of Gran Hotel Pucón)</td></tr>
<tr><td colspan="6">Tuesday, March 15</td></tr>
<tr><td>08:30
18:00</td><td colspan="2">Theme Session S1
(Salon Araucania)</td><td colspan="3">Theme Session S2
(Salon Lonquimay)</td></tr>
<tr><td>18:00
20:00</td><td colspan="5">Poster Session
(S1, S2, S4, S8 - Salon Coñaripe) (S3, S5, S6, S7, S9, GP, W1-W5 - Salon Llaima)</td></tr>
<tr><td colspan="6">Wednesday, March 16</td></tr>
<tr><td>08:30
12:30</td><td>Workshop W1
(Salon Antuco)</td><td>Workshop W2
(Salon Araucania)</td><td>Workshop W3
(Salon Lonquimay)</td><td>Workshop W4
(Salon Lanin)</td><td>Workshop W5
(Salon Tolhuaca)</td></tr>
<tr><td>14:00
18:00</td><td colspan="2">Theme Session S4
(Salon Araucania)</td><td colspan="3">Theme Session S5 (day 1)
(Salon Lonquimay)</td></tr>
<tr><td>18:00
20:00</td><td colspan="5">Poster Session
(S1, S2, S4, S8 - Salon Coñaripe) (S3, S5, S6, S7, S9, GP, W1-W5 - Salon Llaima)</td></tr>
<tr><td colspan="6">Thursday, March 17</td></tr>
<tr><td>08:30
12:30</td><td colspan="2">Theme Session S7
(Salon Araucania)</td><td colspan="3">Theme Session S5 (day 2)
(Salon Lonquimay)</td></tr>
<tr><td>14:00
20:00</td><td colspan="5">Excursions</td></tr>
<tr><td>20:00</td><td colspan="5">Symposium Dinner</td></tr>
<tr><td colspan="6">Friday, March 18</td></tr>
<tr><td>08:30
12:30</td><td colspan="2">Theme Session S8
(Salon Araucania)</td><td colspan="3">Theme Session S9
(Salon Lonquimay)</td></tr>
<tr><td>14:00</td><td colspan="5">Poster Session</td></tr>
<tr><td>15:00</td><td colspan="5">CLOSING SESSION
Plenary
Salon Pucon (Salones Araucania + Lonquimay)</td></tr>
<tr><td>16:00</td><td colspan="5">Outcomes from the Symposium</td></tr>
<tr><td></td><td colspan="5">Comments from the audience</td></tr>
<tr><td></td><td colspan="5">Best Presentations Awards</td></tr>
<tr><td></td><td colspan="5">Closing remarks by Symposium convenors</td></tr>
<tr><td>16:30</td><td colspan="5">The End</td></tr>
</table>

List of Sessions and Workshops

Notes for Guidance

Presentations

In order to allow the sessions to run smoothly, and in fairness to other speakers, all presentations are expected to adhere strictly to the time allocated. All authors should designate at least 3 minutes for questions.

Authors can download their presentations straight to the computers where the session/workshop will be held.

Important: Please rename your files: time-name.ppt (*e.g.* 0900-Smith.ppt, 1530-Kim.ppt).

If complications occur due to incompatibilities between PCs and Macs, Macintosh owners may use their own computers to make presentations.

Posters

Posters will be on display in the *Salon Coñaripe* and *Salon Llaima* from 12:00 on March 14. Two evening poster sessions (with appetizers and drinks) will be held from 18:00-20:00 on March 15 and 16, and one afternoon poster session will be held from 14:00-15:00 on March 18, when poster presenters are expected to be available to answer questions. Posters must be removed at the end of the poster session at 16:30 of March 18.

Internet access

Internet access via wireless LAN will be available at the Gran Hotel Pucón Convention Center (ground level). A few desktop computers will also be available for participants at the Gran Hotel Pucón Convention Center (underground level).

Social activities (for all participants)

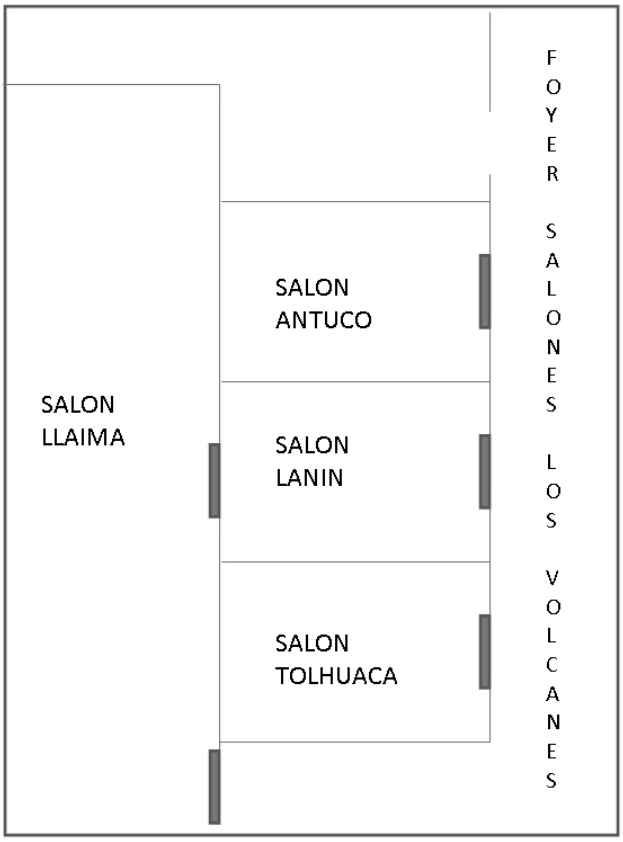
The Welcome Reception will be held on March 14 from 18:30-21:00 at the Ballroom of Gran Hotel Pucón.

The Excursions are scheduled on March 17 from 14:00-20:00.

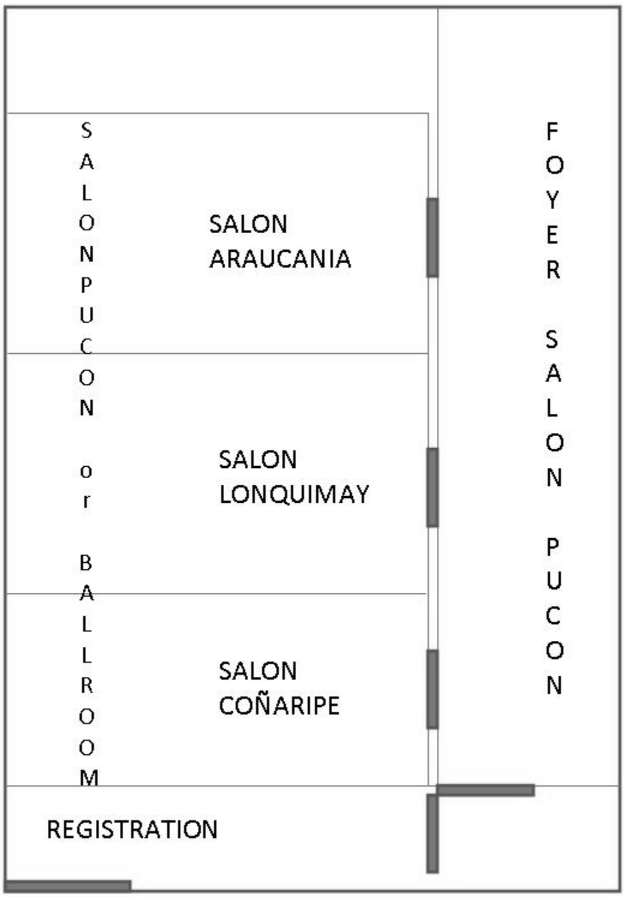
The Symposium dinner will be held on March 17 from 20:00.

Gran Hotel Pucón Convention Center Floor Plan

Ground Floor



Underground Floor



Schedules

March 14

Opening Plenary Session

8:30	Introduction / Welcome
8:50	**Grégory Beaugrand** Climate change and planktonic ecosystems: Detection, understanding and projection (Plenary-7339)
9:30	**Deborah K. Steinberg** Zooplankton role in biogeochemical cycles: Progress and prospects for the future (Plenary-7232)
10:10	***Coffee/Tea Break***
10:30	**Shin-ichi Uye** The giant jellyfish (*Nemopilema nomurai*) bloom in East Asian seas: Causes, consequences and countermeasures (Plenary-7112)
11:10	**Kendra L. Daly** Modes of climate and food web variability in high latitude oceans (Plenary-7277)
11:50	**Torkel Gissel Nielsen** Composition and succession of zooplankton communities: A global comparison (Plenary-7115)
12:30	Session ends

March 14

Session 3 (S3)

Zooplankton life histories: Spatial connectivity, dormancy, and life cycle closure

Co-Convenors:
Hans-Jürgen Hirche (Alfred Wegener Institute, Germany)
Toru Kobari (Kagoshima University, Japan)
Jeffrey A. Runge (School of Marine Sciences and Gulf of Maine Research Institute, University of Maine, USA)

Invited Speaker:
Don Deibel (Memorial University, Canada)

Each zooplankton species has its own set of life history traits, influenced by its taxonomic lineage (*e.g.*, gelatinous zooplankton, copepods, euphausids), the physical characteristics of the environment in which it resides and the suite of other species with which it interacts. In seasonal environments, life histories may include a dormant phase, which may occur at any life stage and vary in intensity from almost complete shutdown of metabolism to merely arrested reproductive activity. Losses from a population due to advection during dormancy or active phases may prevent life cycle closure, for example in upwelling zones, determining which species are dominant. Immigration from other populations may be required to sustain species abundance within a particular region. In this session we encourage presentations that together will depict the variety of zooplankton life histories across all taxonomic groups and how they interact with the physical environment at local, regional or basin scales to determine species abundance and diversity patterns.

14:00	***Introduction by Convenors***
14:05	**Don Deibel and Ben Lowen (Invited)** Life cycles and life history adaptations of pelagic tunicates (S3-7057)
14:30	**Ulf Båmstedt** Explaining the mass occurrence of a deepwater scyphomedusa in Norwegian fjords (S3-6973)
14:50	**Cornelia Jaspers, Thomas Kiørboe, Kajsa Tönnesson and Matilda Haraldsson** The physical characteristics of the Baltic Sea might act as a bottleneck for the *Mnemiopsis leidyi* population expansion in this newly invaded area (S3-7042)
15:10	**Alenka Malej, Vlado Malačič, Andreja Ramšak, Tjaša Kogovšek and Katja Stopar** Spatial connectivity and cycles of *Pelagia noctiluca* (Semaeostomeae, Scyphozoa) (S3-7005)
15:30	**Natasha Henschke, Jason D. Everett, Mark E. Baird, Matthew D. Taylor and Iain M. Suthers** Relative abundance of life history stages of the ubiquitous salp *Thalia democratica* in different water types (S3-7002)
15:50	***Coffee/Tea Break***
16:20	**Shinji Shimode, Mitsuhiro Toratani and Atsushi Tsuda** *Neocalanus* ocean vs. *Calanus* ocean: Implication as characteristics of planktonic ecosystem in the North Pacific (S3-6997)
16:40	**Frédéric Maps, Andrew J. Pershing and Nicholas R. Record** Understanding copepod life-history and diversity using a next-generation zooplankton model (S3-7068)

17:00 **Andrew G. Hirst, Delphine Bonnet, David V.P. Conway and Thomas Kiørboe**
Does predation control adult sex ratios and longevities in marine pelagic copepods? (S3-6964)

17:20 **Leah R. Feinberg, C. Tracy Shaw, William T. Peterson and Hongsheng Bi**
Life history of *Euphausia pacifica* in the northern California current: What can be learned by contrasting field and laboratory studies (S3-7125)

17:40 **Espen Strand, Geir Huse and Webjørn Melle**
Behavior and life-history strategies of Northern krill (*Meganyctiphanes norvegica*) and its impact on population dynamics and spatial distribution: Results from a spatial explicit individual-based model with external forcing (S3-7100)

18:00 Session ends

Posters

S3-6434 **Elahe Sanjarani and Malihe Sanjarani**
Zooplankton in Iranian coastal waters (Oman Sea) during the Pre and Post-Monsoon period

S3-6900 **Benni Winding Hansen**
Physiology and biology of Calanoid copepod eggs

S3-6908 **Hidefumi Fujioka, Ryuji J. Machida and Atsushi Tsuda (*cancelled*)**
Preliminary results on the early life cycle of *Neocalanus plumchrus* and *Neocalanus flemingeri* in the Oyashio region, western north Pacific

S3-6930 **Mary Mar P. Noblezada and Wilfredo L. Campos**
Size distribution, sexual maturity and diet of the chaetognath *Flaccisagitta enflata* along the Pacific Coast and adjacent inland waters of the Philippines

S3-6941 **Yuichiro Yamada, Shuhei Nishida, Martin Graeve and Gerhard Kattner**
Ontogenetic and seasonal variations in lipid and fatty acid composition of the subarctic copepods *Neocalanus cristatus* and *Eucalanus bungii* in the Oyashio region, western North Pacific

S3-6958 **Tone Falkenhaug and Svetlana Sudnik**
Reproductive patterns in pelagic decapod shrimps from the northern Mid-Atlantic Ridge

S3-6962 **Webjørn Melle and Bjørnar Ellertsen**
A high frequency time series of hydrography, nutrients, chlorophyll and *Calanus finmarchicus* life history at Weather Station Mike in the Norwegian Sea during 1997 and 1998

S3-6963* **Séverine Boyer, Isabelle Arzul, Marc Bouvy and Delphine Bonnet**
(*Presenter: Delphine Bonnet on behalf of Séverine Boyer*)
Life strategies of *Acartia* spp. populations in the Thau Lagoon

S3-6970 **Hildur Petursdottir and Astthor Gislason**
Seasonal abundance of zooplankton south of Iceland in relation to environmental variables

S3-6994 **Anabela A. Berasategui, Mónica S. Hoffmeyer and M. Sofía Dutto**
Eurytemora americana egg production and morphology in the Bahía Blanca estuary, Argentina

S3-6995 **Anabela A. Berasategui, Mónica S. Hoffmeyer, Florencia Biancalana and M. Sofía Dutto**
Reproductive strategy and egg morphology of the copepod *Acartia tonsa* in a temperate estuary, Argentina

S3-7001 **Chaolun Li, Guang Yang, Juan Ning and Song Sun**
The response of copepod grazing and reproduction to spring blooms of different species in the Southern Yellow Sea

S3-7023 **Christina B. Augustin and Sandra Kube**
Lifecycle of the scyphozoan moon jellyfish *Aurelia aurita* in the Western Baltic Sea

S3-7027 **Wan Aiyong and Zhang Guangtao**
The dead proportion of copepods in Jiaozhou Bay

S3-7041* **Dellis Montuy Gómez, Jaime Gómez-Gutiérrez, Carmen Rodríguez Jaramillo and Carlos J. Robinson**
(*Presenter: Jaime Gómez-Gutiérrez on behalf of Dellis Montuy Gómez*)
Nyctiphanes simplex embryogenesis synchronization with female molting and gonadal cycles (Crustacea: Euphausiacea) in the Gulf of California

S3-7043 **Ann Bucklin and Leocadio Blanco-Bercial**
Comparative phylogeography and connectivity of zooplankton based on DNA barcodes

S3-7055 **Geneviève J. Parent, Stéphane Plourde, Pierre Joly and Julie Turgeon**
Overlapping size ranges of *Calanus* spp. off the Canadian coast: Impacts on oceanographic surveys

S3-7056 **Geneviève J. Parent, Julie Turgeon, Stéphane Plourde and Pierre Joly**
Hybridization of *Calanus finmarchicus* and *Calanus glacialis* off the Canadian coast

S3-7069 **Cheryl A. Morgan, William T. Peterson, Molly V. Sturdevant, Julie E. Keister, Moira Galbraith, Jesse F. Lamb, David L. Mackas, Joseph A. Orsi, Mary E. Thiess, Marc Trudel and Bruce L. Wing**
Latitudinal gradients in copepod community composition in the Northern California Current and S. Gulf of Alaska during years of varying ocean conditions

S3-7087 **Cesar Vilas, Enrique González-Ortegón, Francisco Baldo, Emilio Pascual and Pilar Drake**
Population dynamic of mysid community and its key role for nursery function in a temperate estuary

S3-7090 **Maria Põllupüü, Mart Simm and Henn Ojaveer**
Selective impact of the predatory cladoceran *Cercopagis pengoi* on zooplankton community in the Gulf of Riga (Baltic Sea)

S3-7121 **Astthor Gislason, Hildur Petursdottir and Teresa Silva**
Life cycle and seasonal vertical distribution of copepods in oceanic subarctic waters north of Iceland

S3-7165* **Se-Jong Ju, Hye Seon Kim, Donhyug Kang, Woongseo Kim and Kyoungsoon Shin**
(*Presenter: Kyoungsoon Shin on behalf of Se-Jong Ju*)
Understanding the importance of the bottom cold water mass as an over-summering refuge for *Euphausia pacifica* in the Yellow Sea

S3-7166 **David W. Pond and Geraint A. Tarling**
Phase transitions of wax esters adjust buoyancy in diapausing *Calanoides acutus*

S3-7167 **Katie Clarke, David W. Pond and Andrew Brierley**
Seasonal lipid dynamics and diapause of *Calanus finmarchicus* in a fjordic environment

S3-7168 **David W. Pond, Geraint A. Tarling and Daniel J. Mayor**
Pressure induced homeoviscous adaptation of cellular membranes in diapausing *Calanoides acutus*

S3-7207 **Elisabeth Halvorsen**
Phenology of reproduction of two calanoid copepods in the Arctic: Life history adaptation and predictability of sea ice break-up

S3-7219 **Gerardo Aceves-Medina, S. Patricia A. Jiménez-Rosenberg, Ricardo Saldierna-Martínez, Reginaldo Durazo-Arvizu and Gilberto Gaxiola-Castro**
Influence of the mesoscale structure off Baja California on the diversity and abundance of the larval fish assemblages

S3-7245* **Naira J. Silva and Rubens M. Lopes**
(*Presenter: Co-Author on behalf of Naira J. Silva*)
Occurrence of copepod carcasses on the inner shelf off Ubatuba (Southeastern Brazil)

S3-7256 **François Carlotti, Zhongfeng Qiu Andrea Doglioli and P. Marsaleix**
The influence of hydrodynamic processes on zooplankton transport and distributions in the North western Mediterranean Sea estimated from a lagrangian model. Application to *Pelagia noctiluca*

S3-7259 **Lionel Eisenhauer, François Carlotti, Frédéric Diaz and Rose Campbell**
Modelling spatial distributions of zooplankton life stages influenced by mesoscale circulation in the North Western Mediterranean Sea during the year 2001

March 14

Session 6 (S6)

Zooplankton in polar ecosystems and extreme environments

Co-Convenors:
Angus Atkinson (British Antarctic Survey, UK)
Carin Ashjian (Woods Hole Oceanographic Institution, USA)

Invited Speaker:
Øystein Varpe (Norwegian Polar Institute, Norway)

Polar waters and their marginal seas are characterised by low, fairly stable temperatures, intense variation in solar radiation amplified by winter ice cover, and high seasonal variation in pelagic primary production. Further, the fastest warming regions on the planet are at high latitudes. These habitats are undergoing dramatic environmental changes such as summer sea ice retreat in the Western Arctic, and are predicted to show the first signs of carbonate under-saturation. The extreme polar conditions require adaptations by micro-, meso-, and macro-zooplankton (herein "zooplankton") including stenothermy, shrinkage, use of sea ice, differing phenologies, seasonal migrations and diet shifts plus pulsed reproduction and slow, strongly seasonal growth. Some of these attributes make polar zooplankton potentially sensitive even to small changes in temperature, sea ice extent, seasonality and the timing of food. Polar ecosystems also can provide glimpses into the future of climate change. They provide a natural test-bed to examine both the sensitivity (*e.g.* physiological limits) and the resilience (*e.g.* behavioural flexibility) of zooplankton. In this session we welcome studies from high latitudes of both hemispheres, examining the response of zooplankton to spatial and temporal environmental variability and change. We welcome also broader scale comparative contributions (of species, regions or hemispheres), especially those that explore the mechanisms of sensitivity or resilience.

14:00	***Introduction by Convenors***
14:05	**Øystein Varpe (Invited)** Adaptations to seasonality and the annual routine perspective for zooplankton (S6-7484)
14:30	**Albert Calbet, Enric Saiz, Karen Riisgaard, Rodrigo Almeda, Ignacio Movilla, Miquel Alcaraz, Sara Zamora and Torkel Gissel Nielsen** Microzooplankton grazing in Arctic waters (S6-6880)
14:50	**Stéphane Plourde, Carin J. Ashjian, Robert G. Campbell and Celia Gelfman** The energy budget of egg production in Calanus glacialis during spring and summer in the Beaufort-Chukchi Seas (S6-7220)
15:10	**Sara Zamora, Torkel Gissel Nielsen and Enric Saiz** Plankton community structure and role of *Oithona similis* on the western coast of Greenland (S6-6883)
15:30	**Sanne Kjellerup, Rasmus Swalethorp, Karen Riisgaard and Torkel Gissel Nielsen** Population dynamics and life strategy of the copepod *Metridia longa* in a Greenlandic fjord, 2010 (S6-6948)
15:50	***Coffee/Tea Break***
16:20	**Ksenia N. Kosobokova and Hans-Juergen Hirche** Is Arctic zooplankton sleeping in the winter? (S6-7135)

16:40 **Humberto E. González, M.G. Mazzocchi, I. Borrione, Ricardo Giesecke, G. Mahadik, M. Marchant, E. Menschel, P. Martin, M. Ribera d´Alcala and Pieter Vandromme**
A phytoplankton bloom controlled by zooplankton grazing during the LOHAFEX iron-fertilisation experiment in the S-W Antarctic Circumpolar Current (S6-6993)

17:00 **Jun Nishikawa, Patricia Kremer, Laurence P. Madin and Erich Horgan**
Diel vertical migration of the pelagic tunicate *Salpa thompsoni* in the Southern Ocean (S6-7193)

17:20 **Miquel Alcaraz, Rodrigo Almeda, Enric Saiz, Albert Calbet, Carlos M. Duarte, Susana Agustí, Rocio Santiago, Juancho Movilla, Alejandro Alonso, Jorge Felipe, Elena Arashkevich and Ulrike Grote**
Arctic zooplankton in a warming scenario: Metabolism, tipping points and stoichiometry of regenerated nutrients (S6-6888)

17:40 **Rubao Ji, Carin J. Ashjian, Robert G. Campbell, Changsheng Chen, Guoping Gao, Cabell Davis, Geoffery Cowles and Robert Beardsley**
Life history and biogeography of *Calanus* copepods in the Arctic Ocean: An individual-based modeling study (S6-6914)

18:00 Session ends

Posters

S6-6928 **Ulrike Grote, Elena Arashkevich, Elisabeth Halvorsen, Anna Pasternak, Raul Primicerio, Konstantin Solovyev and Anastasia Nikishina**
Effect of rising seawater temperature on the survival of the Arctic calanoid copepod *Calanus glacialis*: A laboratory experiment

S6-6947 **Guang-Tao Zhang and Song Sun**
Zooplankton species composition and community structure in Western Arctic Ocean in summer 2003

S6-7013 **Sanne Kjellerup, Rasmus Swalethop, Michael Dunweber, Signe Jung Madsen, Marie Vestergaard Henriksen, Torkel Gissel Nielsen, Benni Winding Hansen and Eva Friis Møller**
Effects of climate changes on the three coexisting *Calanus* species; *C. hyperboreus*, *C. glacialis* and *C. finmarchicus* during the productive season in Disko Bay, West Greenland

S6-7024 **Camilla Svensen, Lena Seuthe, Yulia Vasilyeva, Anna Pasternak and Edmond Hansen**
Zooplankton community across Fram Strait in autumn: Are small copepods and protozooplankton important?

S6-7028 **Cecilie Broms, Webjørn Melle, Lars Johan Naustvoll and Tor Knutsen**
Plankton abundance, community structure and production across an Arctic front

S6-7035 **Enric Saiz, Albert Calbet, Rodrigo Almeda, Juancho Movilla, Eva M. Velasco and Miquel Alcaraz**
Zooplankton feeding in the Artic during a *Phaeocystis* bloom

S6-7044 **Gara Franchy, Claire Schmoker and Santiago Hernández-León**
Grazing activity around the South Shetland Islands (Antarctic Peninsula) during summer

S6-7063 **Konstantin Solovyev and Marit Reigstad**
Three Calanus species populations in the Fram Strait in spring period: Role of hydrological and biological factors

S6-7142 **Amy Maas, Leanne Elder, Heidi Dierssen and Brad A. Seibel**
The metabolic response of Antarctic pteropods (Gastropoda: Mollusca) to food availability

S6-7145 **J. Berge, F. Cottier, Øystein Varpe, P. Renaud, S. Falk-Petersen, A. Aubert, O. Bjærke, J. Hovinen, S. Juul-Madsen and M. Tveit**
Macrozooplankton rather than *Calanus* are responsible for autumn DVM in Arctic fjords and pack ice: Backscatter contribution by net samples compared with acoustics

S6-7173 **C. Tracy Shaw, Robin M. Ross and Langdon B. Quetin**
Effect of sea ice conditions on physiological maturity of female Antarctic krill (*Euphausia superba*) west of the Antarctic Peninsula

S6-7180 **E.L. Orlova, V.A. Ivshin, P. Renaud, Claudia Halsband-Lenk, T.V. Strakhova and I.P. Prokopchuk**
Abundance, structure and biomass of *Calanus hyperboreus* in the Barents Sea

S6-7189 **Kunio T. Takahashi, Atsushi Tanimura and Kenji Saito**
The occurrence of eugregarinid protozoan within the digestive tract of the Antarctic coastal krill *Euphausia crystallorophias*

S6-7197 **Lionel Eisenhauer, Dag Slagstad and Paul Wassmann**
Changes in the production and distribution of Arctic *Calanus* spp. congeners at multi-decadal scales in response to climate warming

S6-7225 **Imme Rutzen, Russell R. Hopcroft and Falk Huettmann**
Assembling pan-arctic patterns of zooplankton abundance

S6-7250 **Margaux Noyon, Stéphane Gasparini, Fanny Narcy and Patrick Mayzaud**
How did the Arctic amphipod *Themisto libellula* cope with high Atlantic water masses input? A 5 month survey in Kongsfjorden

S6-7296 **Jennifer Questel, Russell R. Hopcroft and Cheryl Clarke**
Inter-annual variability of the planktonic communities in the Northeastern Chukchi Sea

S6-7300 **Elizaveta A. Ershova, Russell R. Hopcroft and Ksenia N. Kosobokova**
Broadscale patterns of summer zooplankton communities in the Chukchi Sea during 2004 and 2009

S6-7308 **Fanny Narcy, Margaux Noyon, Stéphane Gasparini, Patrick Mayzaud and Stig Falk-Petersen**
Feeding habits and life strategy of *Oithona similis* in Kongsfjorden (Spitsbergen): Insights from its lipid content

S6-7310 **Anaïs Aubert, Tobias Tamelander and Paul Wassmann**
C, N, and P body concentrations and ratios in high latitude calanoid copepods: A reflection of changes in environmental conditions?

S6-7323 **Cheryl Clarke and Russell R. Hopcroft**
The Arctic Ocean Diversity (ArcOD) data-portal: Zooplankton

S6-7330 **Angus Atkinson, Katrin Schmidt, Sophie Fielding, So Kawaguchi and Paul Geissler**
Are Antarctic krill fecal pellets exported or recycled?

S6-7331 **Katrin Schmidt, Angus Atkinson, Hugh Venables and David W. Pond**
Spring blooms in the Southern Antarctic Circumpolar Current Front (SACCF) support early spawning of Antarctic krill

March 15

Session 1 (S1)

Effects of climate variability on secondary production and community structure

Co-Convenors:
Delphine Bonnet (Université Montpellier 2, France)
Catherine Johnson (Bedford Institute of Oceanography, Fisheries and Oceans Canada)
Angel Lopez-Urrutia (Instituto Español de Oceanografía, Spain)
Anthony Richardson (CSIRO Marine and Atmospheric Research and University of Queensland, Australia)

Invited Speaker:
Mark Ohman (Scripps Institution of Oceanography, UCSD, USA)

Climate variability and change influence zooplankton production and community structure through changes in the physical and chemical environment, as well as through changes in primary producers and zooplankton predator dynamics. Understanding and predicting impacts of climate change on secondary production and zooplankton communities will be critical in the near future to managing aquatic resources and mitigating the impact of climate change and other anthropogenic stressors on aquatic ecosystems. In this session, we encourage presentations that contribute to understanding how climate change influences zooplankton production and community dynamics, including climate effects on zooplankton population growth rates, distribution and abundance, seasonal timing, community structure and interactions, interactions with higher and lower trophic levels, and food web structure. This session will embrace studies of both marine and freshwater systems, a diverse range of zooplankton taxa including microzooplankton and gelatinous zooplankton, and a broad range of approaches including modeling, experimental work, and field observations.

8:30	***Introduction by Convenors***
8:35	**Mark D. Ohman (Invited)** Zooplankton as sentinels of climate change (S1-7271)
9:00	**Karen Wishner, Kendra L. Daly and Brad A. Seibel** Potential effects of climate variability on oxygen minimum zone zooplankton communities (S1-7064)
9:20	**Saskia A. Otto, Rabea Diekman, George Kornilovs, Lutz Postel and Christian Möllmann** Climate-related decadal dynamics in Baltic Sea zooplankton: Interactive and additive effects of bottom-up and top-down controls (S1-6884)
9:40	**Marcos Llope, Priscilla Licandro, King-Sik Chan and Nils Chr. Stenseth** Spatio-temporal variation of the plankton trophic interaction in the North Sea (S1-7050)
10:00	***Coffee/Tea Break***
10:30	**Vivian Montecino, Juan Pablo Oyanedel, Irma Vila and Luis Zúñiga** Limnetic zooplankton structure and distribution in Chilean lakes and reservoirs (S1-7170)
10:50	**William T. Peterson, Cheryl A. Morgan, Hongsheng Bi, Jennifer L. Fisher and Jay O. Peterson** Climate change in the northern California Current ecosystem: Impacts on the community composition and production of zooplankton (S1-7128)
11:10	**Lingbo Li, David L. Mackas, Brian P.V. Hunt, Jake Schweigert, Evgeny A. Pakhomov, Moira Galbraith, John F. Dower, Stephen Romaine, Deborah Faust and Tony J. Pitcher** Large changes in zooplankton communities in the Strait of Georgia, British Columbia, during 1990 – 2007 (S1-7312)

11:30 **Erica Head**
Responses of *Calanus finmarchicus* to climate-related changes in phytoplankton bloom dynamics in Northwest Atlantic shelf and sub-polar gyre regions (S1-7136)

11:50 **Jeffrey A. Runge, Frédéric Maps, Andrew Leising, Andrew J. Pershing, James J. Pierson and David G. Kimmel**
Scenarios of climate change impacts on local production of the subarctic copepod, *Calanus finmarchicus*, in the Gulf of Maine (S1-7293)

12:10 **Viviana Farstey and Amatzia Genin**
Global relationships between water temperature and vertical distribution of zooplankton (S1-7071)

12:30 ***Lunch***

14:00 **Ioanna Siokou-Frangou, Maria-Antonietta Pancucci-Papadopoulou, Dionysios Raitsos, Alex Theocharis, Vassilis Zervakis and Soultana Zervoudaki**
Mesozooplankton in the Aegean Sea (E.Mediterranean Sea): Differences among decades (S1-7153)

14:20 **Sanae Chiba, Hiroya Sugisaki, Tsuneo Ono, Tomoko Yoshiki and Sonia Batten**
Changes in community structure, trophic links, and phenology in a lower trophic level ecosystem in the western subarctic North Pacific during 2001-2009 (S1-7252)

14:40 **Anthony J. Richardson, Felipe Gusmão, Mark Baird, Frank Coman, Claire Davies, Jocelyn Dela-Cruz, Tim Pritchard, Anita Slotwinski and Iain Suthers**
Long-term hydroclimate drivers of zooplankton composition and phenology off eastern Australia (S1-7190)

15:00 **Alessandra Conversi**
Late 1980s regime shifts: Intriguing parallelisms in European (and other) seas (S1-7076)

15:20 **David G. Kimmel, Stéphane Plourde, Andrew Leising, James J. Pierson, Jeffrey A. Runge and Frédéric Maps**
Regional scale climatological forcing of *Calanus finmarchicus* dynamics in the Gulf of Maine and the Gulf of St. Lawrence (S1-7229)

15:40 **Jack Forster, Andrew G. Hirst, David Atkinson and Guy Woodward**
How do organisms change size with changing temperature? Exploring the mechanism of the Temperature-Size Rule (S1-7091)

16:00 ***Coffee/Tea Break***

16:30 **Sophie G. Pitois, Christopher P. Lynam, Nicholas C. Halliday and Martin Edwards**
Long-term changes in the distribution and abundance of selected fish larvae from the CPR (1950-2005) over the UK shelf, in relation to biological and environmental factors (S1-7032)

16:50 **Juan Carlos Molinero, Manuel Hidalgo, Marta Coll, Mirna Batistić, Delphine Bonnet, Michele Casini, Ons Daly Yahia, MªLuz Fernández de Puelles, Lyudmila Kamburska, Mario Lebrato, Priscilla Licandro, Lucía López-López, Davor Lučić, Alenka Malej, Fréderic Mélin, Laura Prieto, Ioanna Siokou-Frangou, Soultana Zervoudaki and Nejib Daly Yahia**
Jellyfish outbreaks in the Mediterranean Sea unveil synergies of climate and fisheries (S1-7320)

17:10 **PieterVandromme, Lars Stemmann, Carmen García-Comas, LaureMousseau, Franck Prejger, Ornella Passafiume, Marc Picheral and Gabriel Gorsky**
Zooplankton response to NW Mediterranean hydroclimatic changes from 1966 to 2010 (S1-7007)

17:30 **Aino Hosia, Tone Falkenhaug and Lars Johan Naustvoll**
Scyphozoan jellyfish trends during 1992-2010 at Flødevigen, Southern Norway (S1-6904)

17:50 Session ends

Posters

S1-6897 **Alexandra V. Temnykh, Viktor V. Melnikov and Mikhail Silakov**
Effects of long-term climate variability on the mesoplankton community structure in the Black Sea coastal areas

S1-6898 **Alexandra V. Temnykh, Viktor V. Melnikov and Mikhail Silakov**
Regional differences in water temperature impact on coastal mesoplankton communities

S1-6910 **Jaime Gómez-Gutiérrez, Samuel Martínez-Gómez and Carlos J. Robinson**
Seasonal growth, molting and egg production rates of *Nyctiphanes simplex* (Crustacea: Euphausiacea) in the Gulf of California

S1-6918 **Jessica Garzke and Ulrich Sommer**
The response of zooplankton body size to warming

S1-6923 **Elena P. Dulepova**
Differences on zooplankton productivity in the western and eastern Bering Sea in the "warm" and "cold" periods

S1-6924 **Alexander V. Zavolokin**
Composition, distribution and dynamics of large-size jellyfish in the Bering, Okhotsk, and Japan Seas and northwestern Pacific Ocean

S1-6940 **Hongsheng Bi, William T. Peterson and Paul T. Strub**
Alongshore transport and zooplankton communities in the northern California Current system

S1-6975 **Lutz Postel**
Specific long-term variability of Baltic Sea zooplankton stocks due to environmental and anthropogenic influences

S1-6979* **Christopher P. Lynam, Martin Lilley, Thomas Bastian, Tom Doyle, Steven Beggs and Graeme Hays**
(*Presenter: Sophie Pitois on behalf of Christopher P. Lynam*)
Have jellyfish in the Irish Sea benefited from climate change and overfishing?

S1-6987 **Désirée Tommasi, Evgeny A. Pakhomov and Brian P.V. Hunt**
Assessing the environmental drivers of interannual variation in mesozooplankton community structure: Insights from field observations in a Canadian fjord

S1-7003 **Min-Chul Jang, Kyoungsoon Shin, Hyun-Ho Shin and Young-Ok Kim**
Egg hatching of copepod in hypoxic zone

S1-7008 **Sünnje L. Basedow, Meng Zhou and Kurt S. Tande**
Growth and mortality within a mesozooplankton community at the polar front

S1-7015 **Germán A. Kopprio, M. Celeste López-Abbate, Gerhard Kattner, R. Hugo Freije, Mónica S. Hoffmeyer and Rubén J. Lara**
Effects of climate change on the zooplankton lipid dynamics in coastal water bodies: A case-study in a brackish lake of Argentina

S1-7049 **Claire Schmoker and Santiago Hernández-León**
Trophic links and variability of the Canary Current system planktonic community in cold and warm years: An end-to-end approach

S1-7054 **Marijana Miloslavić, Davor Lučić, Juan Carlos Molinero, Barbara Gangai, Ivona Onofri and Adam Benović**
Compensatory dynamics of zooplankton long term changes. Example from a marine protected are in the South Adriatic Sea

S1-7074* **Patrick H. Ressler, Alex De Robertis, Phyllis J. Stabeno, Joseph D. Warren, Joy N. Smith and Stan Kotwicki**
(*Presenter: Joseph D. Warren on behalf of Patrick H. Ressler*)
Using an acoustic index of euphausiid abundance to understand the impact of fish predation and climate conditions on the euphausiid standing stock of the Bering Sea shelf

S1-7089 **Maria Põllupüü, Mart Simm and Henn Ojaveer**
Abrupt abundance changes in copepod abundance in the coastal Baltic Sea at a time-scale of fifty years

S1-7122 **Astthor Gislason, Hildur Petursdottir and Teresa Silva**
Inter-annual variability in abundance of *Calanus* spp. in oceanic subarctic waters north of Iceland in relation to environmental conditions

S1-7138 **Nadine Schulz, Jasmin Renz, Janna Peters and Pedro Martínez Arbizu**
Adaptation potential of the calanoid copepod *Acartia tonsa* to multiple environmental stressors

S1-7176 **Claudia Castellani and Priscilla Licandro**
Do species-specific differences of copepod life cycle and ecology contribute to multi-decadal variability in abundance across the north Atlantic basin?

S1-7183 **Melisa D. Fernández Severini, Anabela A. Berasategui, Valeria A. Guinder, M. Clara Menéndez, Florencia Biancalana, M. Sofía Dutto, M. Celeste López Abbate and Mónica S. Hoffmeyer**
Long-term trend in the mesozooplankton abundance in a southwestern temperate estuary (Bahía Blanca Estuary, Argentina)

S1-7201 **Anu Vehmaa, Andreas Brutemark, Jonna Engström-Öst, Elena Gorokhova, Hedvig Hogfors and Towe Holmborn**
Copepod reproduction and oxidative stress in a future climate scenario: Effects of lowered pH, elevated temperature and a toxic cyanobacterium

S1-7236 **Anita Slotwinski, Frank Coman, Claire Davies, Graham Hosie, James McLaughlin, David McLeod, Mark Tonks, Joanna Strzelecki and Anthony J. Richardson**
Plankton observing in Australia: The Australian Continuous Plankton Recorder (AusCPR) survey

S1-7237 **Claire Davies, Pru Bonham, Frank Coman, Tim Lynch, Anita Slotwinski, Peter A. Thompson, Mark Tonks and Anthony J. Richardson**
Plankton observing in Australia: Plankton from the Australian National Reference Stations

S1-7238 **B.H.R. Othman, J.G. Greenwood, A. David McKinnon, Peter C. Rothlisberg and Anthony J. Richardson**
Spatial and temporal distribution of copepod diversity and abundance in the Gulf of Carpentaria, Australia

S1-7244 **Aiko Tachibana, Takashi Ishimaru and Hiroshi Itoh**
Seasonal variation in copepod community structure in Tokyo Bay, Japan

S1-7253 **Danilo L. Calliari, Guillermo Cervetto, Rafael Castiglioni and Laura Rodríguez-Graña**
Abundance-diversity-environment relationship: The case of copepod assemblages in the Rio de la Plata estuary

S1-7266 **Tulia Martinez, Alan Giraldo and Efrain Rodríguez-Rubio**
Fish larvae assemblage during El Niño and La Niña 2007 in the Pacific Ocean of Colombia

S1-7278 **Ramiro Riquelme-Bugueño, Samuel E. Hormazábal, Marco Correa-Ramírez, Rubén Escribano and Sergio Núñez**
Mesoscale variability and its impact on the euphausiid community off Central Chile during the spring 2007

S1-7285 **Catherine L. Johnson, Jeffrey A. Runge and K. Alexandra Curtis**
Interannual variability in the Scotian Shelf (Northwest Atlantic) zooplankton community and influence on the Gulf of Maine

S1-7287 **Elda Pinedo, Yasmín Escudero and Patricia Ayón**
Abundance and composition variability of copepods in the northern Humboldt Current system

S1-7290 **Russell R. Hopcroft, Cheryl Clarke, Christine T. Baier and Jeffery M. Napp**
Egg production rates of *Pseudocalanus mimus* and *Pseudocalanus newmani* in the coastal Gulf of Alaska

S1-7299* **Lucía López-López and Juan Carlos Molinero**
(*Presenter: Juan Carlos Molinero on behalf of Lucía López-López*)
Estimating the effect of environmental conditions on the seasonality and outbreak periodicity of *Pelagia noctiluca* in the Mediterranean Sea

March 15

Session 2 (S2)

Ecological interactions: Links to upper and lower trophic levels

Co-Convenors:
Sanae Chiba (Research Institute for Global Change, JAMSTEC, Japan)
Enric Saiz (Institut de Ciencies del Mar, Spain)

Invited Speaker:
Diana Stoecker (University of Maryland Center for Environmental Science, USA)

Zooplankton play a key role in the pelagic realm as a major link between primary producers and higher trophic levels, either directly or indirectly via protozooplankton, therefore being subject to either bottom-up and top-down control. Regionally-specific differences in food web structure and ecological interactions between trophic levels largely influence not only the biological productivity but also the biogeochemical processes acting in the region, such as the efficiency of the biological carbon pump. Recent studies have reported sound changes in zooplankton communities responding to various climatic and anthropogenic forcing, such as species diversity and size composition, seasonality, geographical distribution, *etc.*, yet the mechanisms and consequences of those changes in terms of the functioning of the system and biogeochemical processes in the water column have not been fully investigated. In this session we aim for a better understanding of the complexity of the trophic interactions mediated by micro- and mesozooplankton, either as prey or as predator, in marine food webs, and in particular highlight studies that help explain how the above-mentioned spatio-temporal changes in zooplankton communities would affect biological production as well as biogeochemical processes. We expect papers on this scope, ranging from the smallest scales dealing with individual behavior to the largest scales dealing with long-term community change analysis, based on either laboratory experiments, field observation, and model simulation.

8:30	***Introduction by Convenors***
8:35	**Diane <u>Stoecker</u>, Kristen Blattner, Alison Weigel and Dean Stockwell (Invited)** Acquired phototrophy in ciliates: Does it boost trophic transfer to mesozooplankton? (S2-6988)
9:00	**Michael <u>Landry</u> and Michael R. Stukel** Plankton trophic structure and food-web fluxes in the eastern equatorial Pacific (S2-7072)
9:20	**Sylvain <u>Lenoir</u>, Grégory Beaugrand and Jean-Claude Dauvin** Projections of changes in the spatial distribution of zooplankton for the end of this century: Consequences for higher trophic levels (S2-6989)
9:40	**Lindsay J. <u>Sullivan</u>, Wim Kimmerer and Joan Lindberg** Impacts of introduced copepods on the growth and survival of planktivorous fish in the San Francisco Estuary (S2-7103)
10:00	***Coffee/Tea Break***
10:30	**Daniel <u>Bevan</u>, John F. Dower, Marc Trudel and Asit Mazumder** Spatial variability in lipid content and fatty acid profiles of macrozooplankton from coastal British Columbia, Canada (S2-7067)
10:50	**Hiroya <u>Sugisaki</u>, Kiyotaka Hidaka, Tadafumi Ichikawa, Yuuichi Hirota, Yutaka Hiroe, Mikiko Kuriyama, Toru Udagawa and Kaoru Nakata** Long-term variation of the plankton community in the Kuroshio warm current area; the spawning ground of Japanese sardine (S2-7191)

11:10 **Corinne Pomerleau, Steven H. Ferguson, Véronique Lesage, Gesche Winkler and Wojciech Walkutz**
Zooplankton prey species and foraging ecology of bowhead whales (*Balaena mysticetus*) in the Canadian High Arctic: Insights from stable isotope and stomach content analyses (S2-7137)

11:30 **Ainhoa Lezama-Ochoa, Michael Ballón, Daniel Grados, Mathieu Woillez, Udane Martinez, Guillermo Boyra, Xabier Irigoien and Arnaud Bertrand**
Acoustic study of the macrozooplankton community in the Bay of Biscay: Diel vertical migration, spatial patterns and interaction with pelagic fish (S2-7218)

11:50 **Gareth L. Lawson, Andone C. Lavery, Peter H. Wiebe, Timothy P. White and Reny B. Tyson**
Aggregation of euphausiids and interaction with higher predators in regions of abrupt topography of the northwest Atlantic (S2-7319)

12:10 **Mette Dalgaard Agersted and Torkel Gissel Nielsen**
The functional biology of krill (*Thysanoessa raschii*) with focus on its ecological role in a Greenlandic fjord (S2-7022)

12:30 ***Lunch***

14:00 **Michael J. Dagg, Bruce W. Frost and Jan A. Newton**
Phytoplankton ingestion by populations of dielly migrating copepods and euphausiids in Dabob Bay, a coastal fiord in Washington, USA (S2-7327)

14:20 **Julieta Antacli, Marina Sabatini, Rut Akselman and Daniel Hernández**
Seasonal variability of feeding and reproductive activity of the copepods *Drepanopus forcipatus* and *Calanus australis* in the Southern Patagonian Shelf: Post-bloom *vs.* early- bloom conditions (S2-6932)

14:40 **Jonna Engström-Öst, Elena Gorokhova, Hedvig Hogfors, Andreas Brutemark and Anu Vehmaa**
Zooplankton and algal blooms – Case studies from the Baltic (S2-7148)

15:00 **Tone Falkenhaug and Padmini Dalpadado**
Diet composition and food selectivity of Sprat (*Sprattus sprattus*) in Hardangerfjord, a fjord off western Norway (S2-6957)

15:20 **Leonardo Castro, Gabriel Claramunt, Humberto E. González, María C. Krautz, Alejandra Llanos-Rivera, Joyce Méndez, Wolfgang Schneider and Samuel Soto**
The effect of contrasting feeding environments on anchoveta egg quality during the spawning season off central Chile (S2-7182)

15:40 **Wim Kimmerer**
Biotic *vs.* physical control of zooplankton in estuaries (S2-7004)

16:00 ***Coffee/Tea Break***

16:30 **Joseph D. Warren, Susan E. Parks, David Wiley, Douglas P. Nowacek and Ari S. Friedlaender**
Measurements of zooplankton preyfield densities over small spatial and temporal scales and their effect on the behavior of individual baleen whale predators (S2-7048)

16:50 **Klas O. Möller, Christian Möllmann, Axel Temming and Michael St. John**
Resolving the small scale distribution of plankton and marine snow: Unravelling the role of thin layers as assessed with optical techniques (S2-7025)

17:10 **Anastasia Nikishina, Alexander Drits and Yulia Vasilyeva**
The role of *Noctiluca scintillans* in the trophic dynamics of the Black Sea plankton community (S2-7070)

17:30 **Lene Friis Møller and Peter Tiselius**
Population dynamics and predation impact of the introduced ctenophore Mnemiopsis leidyi in the Gullmars fjord, west coast of Sweden (S2-7246)

17:50 Session ends

Posters

S2-6899 **Alexandra V. Temnykh, Viktor V. Melnikov and Mikhail Silakov**
One more guilty player in the dramatic changes in the plankton of the Black Sea – *Acartia clausi*

S2-6912 **Joanna Strzelecki and Shaofang Wang**
Influence of physical oceanography on the diet of size fractionated zooplankton of Western Australian coast: Insight from fatty acids

S2-6922 **Maxim Koval and Anastasia Morozova**
Zooplankton as food supply to the marine pelagic fishes in the Kamchatka waters

S2-6925 **Natalia T. Dolganova**
Zooplankton of the Sea of Japan as potential prey for livestock growing of salmon

S2-6933 **Marina Sabatini, Rut Akselman, Rubén Negri, Ricardo Silva, Norma Santinelli, Viviana Sastre, Cristina Daponte, Julieta Antacli, Vivian Lutz, Valeria Segura, Raúl Reta and Mónica Gil**
Mesozooplankton community structure and trophic interactions in the Southern Patagonian Shelf (SW Atlantic, Argentina, 47°-55°S)

S2-6937 **Karyn D. Suchy and John F. Dower**
Bridging the gap between food quality and secondary production in a highly productive fjord in British Columbia, Canada

S2-6938 **Gisela Figueiredo, Betina Kozlowsky-Suzuki, Francisco Matos and Jean Valentin**
Grazing and egg production of the copepod *Acartia tonsa* in a highly eutrophic bay, Rio de Janeiro, Brazil

S2-6951 **Fabien Lombard, Selander Erik and Kiørboe Thomas**
Active food selection in appendicularians

S2-6966 **Espen Bagøien, Webjørn Melle and Stein Kaartvedt**
Seasonal dynamics of *Calanus finmarchicus* in relation to environmental factors in the Norwegian Sea: A multiyear basin-scale analysis

S2-6978* **Christopher P. Lynam, Sophie G. Pitois, Nicholas C. Halliday and Martin Edwards**
(*Presenter: Sophie Pitois on behalf of Christopher P. Lynam*)
Spatio-temporal patterns in abundance of larval fish from Continuous Plankton Recorder (CPR) surveys in the North, Celtic and Irish Seas (1950-2005)

S2-6983 **Tania FitzGeorge-Balfour, Andrew G. Hirst, Cathy H. Lucas and Jamie Craggs**
The influence of prey size, sex and behaviour on predation by the scyphomedusa *Aurelia aurita*

S2-6999* **Natalya Buslova, Anna Dubinina and Oleg Tepnin**
(*Presenter: colleague on behalf of Anna Dubinina*)
Spring diurnal dynamics of ichthyo- and zooplankton in a deep canyon in Avachinsky Gulf (South-East Kamchatka) in 2006-2007

S2-7012 **Sari L.C. Giering, Richard Sanders, Richard S. Lampitt, Alex J. Poulton and Daniel J. Mayor**
Do mesozooplankton cause HNLC conditions in the high-latitude North Atlantic?

S2-7014 **Joseph S. Paimpillil**
The pelagic food web in Cochin backwaters: The proliferation of micro-zooplankton

S2-7026 **Gisela Figueiredo, Fabiana Mendes, Adriana Valente and Jean Valentin**
Diet and prey selection of the chaetognath *Parasagitta friderici* in a eutrophic bay in Rio de Janeiro, Brazil

S2-7046 **David Opazo and Cristian A. Vargas**
Effects of river discharge in the individual and community grazing rates of planktonic copepods in a seasonal upwelling system

S2-7047 **Paulina Y. Contreras, Cristian A. Vargas and José Luis Iriarte**
The relative importance of phototrophic, heterotrophic, and mixotrophic nanoflagellates in the microbial food web dynamic of a river-influenced coastal area

S2-7053 **Marijana Miloslavić, Juan Carlos Molinero, Davor Lučić, Barbara Gangai, Ivona Onofri and Adam Benović**
Seasonal habitat utilization of *Calanus helgolandicus* in semi-enclosed marine lakes ("Veliko jezero", MPA „Mljet", South Adriatic Sea)

S2-7082 **Anne Slaughter, Toni Ignoffo and Wim Kimmerer**
Predatory impact and reproductive rate of *Acartiella sinensis*, an introduced predatory copepod in San Francisco Estuary

S2-7093 **Lin Qun, Jin Xian-Shi and Zhang Bo**
Trophic interactions of jellyfish blooms with fisheries in the Yellow Sea

S2-7119 **Toni Ignoffo, Alison Gould, Anne Slaughter and Wim Kimmerer**
How they survive: The growth and development of copepods in the food limited San Francisco Estuary

S2-7130 **Riguel F. Contente, Marina F. Stefanoni and Leonardo Kenji Miyashita**
The role of planktonic copepods in the diet of fishes from the subtropical Estuarine Complex of Paranaguá Bay, southern Brazil

S2-7150* **Outi Setälä**
(*Presenter: colleague on behalf of Outi Setälä*)
Mnemiopsis *vs.* Aurelia: The role of gelatinous top predators in the northern Baltic Sea food web

S2-7177 **Rodrigo A. Martínez and Albert Calbet**
Use of vital fluorochromes in microzooplankton grazing experiments

S2-7194 **Elvire Antajan, Stéphane Gasparini, Marie-Hermande Daro and Michèle Tackx**
Contribution of herbivory to the diet of the copepod *Temora longicornis* (Müller) in Belgian coastal waters

S2-7233 **Joseph Dominic H. Palermo, Aletta T. Yñiguez, Marianne Camoying, Christine Barrera, Aldwin Almo, Christopher Mendoza, Lourdes J. Cruz and Rhodora V. Azanza**
Mesozooplankton grazing activity during a bloom dominated by *Pyrodinium bahamense var. compressum* in Sorsogon Bay, Philippines

S2-7251 **Martin Ogonowski, Jon Duberg and Sture Hansson**
Intraspecific differences in diel vertical migration in a Baltic Sea Mysis species (*Mysis salemaai*, *Mysidacea*, *Crustacea*), revealed by stable isotopes, C:N ratios and genetic markers

S2-7270 **Hedvig Hogfors, Anu Vehmaa, Towe Holmborn, Susanna Hajdu, Jonna Engström-Öst, Andreas Brutemark and Elena Gorokhova**
Stimulating effects of bloom forming cyanobacteria on copepod reproduction and development

S2-7321 **Juan Carlos Molinero, Katarina Kanevceva and Cristian A. Vargas**
Plankton dynamics in a changing world. Compensatory dynamics and risks for ecological shifts

S2-7337 **Anu Vehmaa, Anke Kremp, Timo Tamminen, Hedvig Hogfors, Kristian Spilling and Jonna Engström-Öst**
Copepod reproductive success in experimentally modified spring phytoplankton communities

March 16

Workshop 1 (W1)

Zooplankton Individual Based Models

Co-Convenors:
Harold P. Batchelder (Oregon State University, USA)
Douglas C. Speirs (University of Strathclyde, UK)

Invited Speaker:
Wendy C. Gentleman (Dalhousie University, Canada)

This workshop will review the use of individual-based models (IBMs) in zooplankton ecology, and the ongoing debate between those favouring density-based population models and those favouring more flexible, but more complex, simulation approaches.

Individual-based models are population models in which individual organisms, or quasi-individuals representing homogeneous groups of individuals, are explicitly represented as discrete elements of a computer simulation. Individuals have their own state variables (or i-state configuration), such as age, size, developmental stage, and physiological condition; population-level dynamics arise as emergent properties of the interactions among individuals and between individuals and their environment. This approach contrasts with population-level models (PLM), or aggregated mathematical models, in which population processes are described by relationships between densities of individuals. Although PLMs can represent individual properties, they do so through an i-state distribution over a population rather than explicitly representing individuals.

One of the main appeals of IBMs is that they provide an easy way of capturing population heterogeneity, or inter-population variability, because stochastic processes impacting individuals can readily be incorporated into simulations. When non-linear rate processes, the functional feeding response for example, determine population growth, the mean behaviour need not necessarily correspond to that predicted by using the underlying mean rates in a deterministic PLM. Because corresponding IBMs represent population heterogeneity explicitly and the population level outcomes emerge from this, such difficulties are side-stepped. A second advantage is that is much easier to introduce behavioural rules, especially those relating to movement, which can be extremely hard to represent in PLMs in a mathematically compact way. The inclusion of diel vertical migration in IBMs of marine zooplankton, for example, has helped to demonstrate the importance of such behaviour in the retention of populations in productive coastal upwelling zones.

The most fundamental difference between IBMs and PLMs is the continuum assumption underlying PLMs. At high trophic levels, when individual organisms are sparse, the concept of density becomes problematic, and IBMs are a natural tool. By contrast, for abundant and relatively homogeneously-distributed organisms the computational cost of representing individuals over large areas can be prohibitive. Many zooplankton populations, with complex life-histories and behaviours, and widespread but often patchy distributions, fall somewhere in the centre of this spectrum, thereby making the choice of modelling approach particularly problematic. Computational costs, and the large number of often un-measurable parameters, also mean that IBMs are not practical tools when moving away from single species zooplankton models to include coupling to higher and lower trophic levels. The workshop will focus on new methods and current challenges in the unification of individual level and population level approaches.

8:30 *Introduction by Convenors*

8:35 **Wendy C. Gentleman (Invited)**
Thinking outside the Z-box: How Individual-Based Models (IBMs) can advance zooplankton ecology (W1-7328)

9:00 **Gaël Dur, Sami Souissi and Jiang-Shiou Hwang**
Individual Based Model for the phenology of *Eurytemora affinis* from the Seine Estuary, France (W1-7240)

9:20 **Douglas C. Speirs and Michael R. Heath**
Modelling *Calanus finmarchicus* in the Irminger Sea: From individuals to populations (W1-7340)

9:40 **Matteo Sinerchia, Wes R. Hinsley, Anthony J. Field and John D. Woods**
Using an Individual Based Model with four trophic levels to model fisheries recruitment (W1-7124)

10:00 *Coffee/Tea Break*

10:30 **Jeffrey G. Dorman, Thomas M. Powell, William J. Sydeman and Steven J. Bograd**
Modeled krill distribution in the California Current from 1990-2005 (W1-7309)

10:50 **Brie Lindsey and Harold P. Batchelder**
North Pacific krill production: A bioenergetic model for *Euphausia pacifica* in the California Current System (W1-7307)

11:10 **Harold P. Batchelder and Brie Lindsey**
Comparison of IBM and concentration based approaches to modeling krill growth and population dynamics (W1-7288)

11:30 Discussion

12:30 Workshop ends

Poster

W1-7210 **Samuel Soto-Mendoza, Leonardo Castro, Carolina Parada and Joyce Méndez**
Retention of *Engraulis ringens* eggs and larvae, connectivity among spawning and recruitment zones, and their relationship with invertebrate predators and larval food distributions in the southern part of the Humboldt Current

March 16

Workshop 2 (W2)

Advances in genomic and molecular studies of zooplankton

Co-Convenors:
Erica Goetze (University of Hawaii at Manoa, USA)
Ryuji Machida (Smithsonian Institution, National Museum of Natural History, USA)
Katja Peijnenburg (Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, The Netherlands)

Invited Speaker:
Carol Eunmi Lee (Center of Rapid Evolution (CORE), University of Wisconsin, USA)

Molecular techniques have provided important insights into a number of aspects of zooplankton ecology. For example, genetic markers have been used to characterize the population structure of zooplankton species, to assess the phylogenetic relationships among extant taxa, and to test the specificity of their trophic niche. Phylogeographic studies have also added a historical perspective to understanding contemporary species distributions and demography. New zooplankton species are being discovered via molecular studies, and research in DNA Barcoding and community meta-genetics promises to greatly accelerate efforts to assess zooplankton diversity in a range of ocean environments. These diverse ongoing research lines rely on both conventional and emerging molecular techniques, and address long-standing questions in biological oceanography. The purpose of this workshop is to assess the current state-of-the-field of molecular and genomic studies of marine zooplankton, and to discuss key research areas that could be significantly advanced through creative application of existing and emerging molecular techniques. For example, we are interested in how molecular approaches could inform interdisciplinary studies of (1) the effect of changing climate on zooplankton physiology, distribution, or feeding ecology, (2) the role of biodiversity in ecosystem function, and (3) the role of mesozooplankton in structuring pelagic food webs through trophic ecology, among others. We envision a workshop with a number of short presentations from the variety of active research areas in zooplankton molecular ecology, followed by discussion focused on specific research questions.

8:30 ***Introduction by Convenors***

8:35 **Carol Eunmi Lee, Greg Gelembiuk, Joana Silva, Marijan Posavi, Michael Kiergaard, Brian Eads, Davorka Gulisija and Yuseob Kim (Invited)**
Rapid evolution during independent copepod invasions into novel environments (W2-7120)

9:00 **Petra H. Lenz, R. Patrick Hassett, Paola Batta Lona, Ebru Unal, Benjamin King, Ann Bucklin and David W. Towle**
Microarray studies in a calanoid copepod, *Calanus finmarchicus* (W2-7105)

9:15 **Ebru Unal, Petra H. Lenz, David Towle and Ann Bucklin**
Gene expression analysis of time-series collections of *Calanus finmarchicus* in the Gulf of Maine, NW Atlantic Ocean (W2-7066)

9:30 **Mattias L. Johansson, Leah R. Feinberg, Michael A. Banks and William T. Peterson**
A comparison of the mitochondrial genomes of five species of North Pacific krill (W2-6942)

9:45 **Silke Laakmann, Inga Mohrbeck, Thomas Knebelsberger and Michael J. Raupach**
Do we know the known? Zooplankton biodiversity of the North Sea (W2-7160)

10:00 ***Coffee/Tea Break***

10:30 **Pennie Lindeque**
Molecular identification of zooplankton: 10 years on (W2-6960)

10:45 **Jaime Gómez-Gutiérrez, Michaela C. Strüder-Kypke, Denis H. Lynn, C. Tracy Shaw, Alejandro López-Cortés, Mario J. Aguilar-Méndez and Carlos J. Robinson**
Genetic evidence of distinct new *Collinia* species, parasitoids of krill from the Bering Sea to the Baja California peninsula region (W2-6909)

11:00 **Paolo Simonelli, Christofer Troedsson, Hans H. Jakobsen, Albert Calbet, Marc E. Frischer and Jens C. Nejstgaard**
Calanus spp. feeding rates on a diatom species estimated by quantitative PCR (W2-6965)

11:15 **Tatiana Rynearson, Edward Durbin, Alison Cleary and Maria Casas**
DNA analysis of prey in zooplankton: From gut contents to feeding rates (W2-7217)

11:30 **Katja T.C.A. Peijnenburg, Mirna Batistić, Lisa E. Becking, and Rade Garić**
Zooplankton populations isolated in marine lakes: Natural laboratories of evolution? (W2-7065)

11:45 **Hiroomi Miyamoto, Ryuji J. Machida and Shuhei Nishida**
Genetic diversity of pelagic chaetognaths (W2-6950)

12:00 **Erica Goetze and David B. Carlon**
Does habitat specialization drive population genetic structure of oceanic zooplankton? (W2-7213)

12:15 Discussion

12:40 Workshop ends

Posters

W2-6968 **Georgina Cepeda, Leocadio Blanco-Bercial, Ann Bucklin, Corina Berón and María Delia Viñas**
Molecular systematics and biogeography of *Oithona* spp. of the Atlantic Ocean

W2-6974 **Ryuji J. Machida, Laetitia Plaisance, Christopher P. Meyer, Jonathan Geller and Nancy Knowlton**
Environmental genetic analysis of coral reef metazoan communities

W2-7037 **Lidia Yebra, Delphine Bonnet, Roger P. Harris, Pennie Lindeque and Katja T.C.A. Peijnenburg**
Barriers in the pelagic: Population structuring of *Calanus helgolandicus* and *C. euxinus* in European waters

W2-7077 **Paola G. Batta-Lona, Rachel O'Neill, Craig Obergfell and Ann Bucklin**
Adaptation in a changing antarctic environment: Transcriptomics of the southern ocean salp, Salpa thompsoni

W2-7161 **Inga Mohrbeck, Silke Laakmann, Thomas Knebelsberger and Michael J. Raupach**
First insights into the molecular diversity of the North Sea zooplankton

W2-7317 **Elena Gorokhova**
Growth strategies of the invasive cladoceran *Cercopagis pengoi* in the Baltic Sea, and the molecular basis for its invasion success

March 16

Workshop 3 (W3)

Updates and comparisons of zooplankton time series

Co-Convenors:
David Mackas (Institute of Ocean Sciences, Fisheries and Oceans Canada)
Martin Edwards (Sir Alister Hardy Foundation for Ocean Science, UK)

Invited Speaker:
Jenny Huggett (Department of Environmental Affairs, South Africa)

Zooplankton time series data are becoming not only more available, but also more widely used as diagnostics of change in marine ecosystems. Since the last International Zooplankton Symposium (2007), a lot has happened. Several new time series sampling programs (rich but brief in 2007) have become long enough to support broader analyses. SCOR Working Group 125 carried out comparisons among many of the earlier and longer time series. New visualization and statistical tools have been developed and applied. And several ocean regions have undergone very strong fluctuations of climate and zooplankton composition. For the 2011 workshop, part of the schedule will be contributed papers. We continue to be especially interested in between-regional teleconnections of decadal fluctuations, and in zooplankton time series that go beyond biomass to include information on variability of community composition, zoogeographic distributions, phenology, and/or physiological condition, and in papers that examine the role of zooplankton in marine ecosystem change and resilience. However, we will also reserve time for on-site demos, discussions, and synthesis efforts (so please bring your laptops, stocked with data tables and favorite analysis tools in addition to your polished presentations).

8:30	***Introduction by Convenors***
8:35	**Jenny Huggett, Todd D. O'Brien, Hans Verheye, Ángel López-Urrutia, Patricia Ayón, Rubén Escribano, Larry Hutchings, Anja Kreiner, David L. Mackas, Mark D. Ohman, William T. Peterson and Chris Reason (Invited)** Zooplankton time series from eastern boundary upwelling ecosystems: Within- and between-system comparisons (W3-7116)
9:00	**Patricia Ayón, Gordon Swartzman, Pepe Espinoza and Arnaud Bertrand** Long term changes in zooplankton size distribution in the Peruvian Humboldt Current System: Conditions favouring sardine or anchovy (W3-7075)
9:15	**Todd D. O'Brien** The COPEPOD Interactive Time-series Explorer (COPEPODITE) (W3-7230)
9:30	**MªLuz Fernández de Puelles and Todd D. O'Brien** Zooplankton trends in an oligotrophic open area of the Balearic Sea (central western Mediterranean) (W3-7095)
9:45	**Pierre Helaouet, Martin Edwards and Grégory Beaugrand** Understanding populations changes in time due to niche requirements (W3-6886)
10:00	***Coffee/Tea Break***
10:30	**Claudia Halsband-Lenk and Elvire Antajan** Comparative time series analyses in the English Channel (W3-7199)
10:45	**Catherine L. Johnson, Pierre Pepin and Michel Harvey** Interannual variability in abundance and seasonal timing of dominant species, immigrant groups, and functional groups at six stations in the northwest Atlantic (W3-7284)

11:00 **Kazuaki Tadokoro, Yuji Okazaki, Tsuneo Ono and Hiroya Sugisaki**
Recent changes of meso-zooplankton community in the western North Pacific Ocean (W3-7228)

11:15 **William T. Peterson, Cheryl A. Morgan, Jennifer L. Fisher, Jay O. Peterson and Hongsheng Bi**
15 years of biweekly sampling along the Newport Hydrographic Line: An update (W3-7140)

11:30 **David L. Mackas**
Flow-field fluctuations *vs.* warming trend: What is driving meridional shifts in zooplankton distribution ranges and community dominance? (W3-7080)

11:45 Group Discussion and Data Exchange

12:45 Workshop ends

Posters

W3-6961 **James Highfield, Damien Eloire, David V.P. Conway, Pennie Lindeque, Martin Attrill and Paul Somerfield**
Seasonal dynamics of meroplankton assemblages at Station L4

W3-7241 **Gaël Dur, Syuhei Ban, Sami Souissi, Emi Doi, Shinsuke Oomae, Takashi Morita and Yoichiro Sakai**
Multiscale temporal variability of *Eodiaptomus japonicus* in Lake Biwa

March 16

Workshop 4 (W4)

Impacts of ocean acidification

Co-Convenors:
So Kawaguchi (Australian Antarctic Division, Australia)
M. Brady Olson (Western Washington University, USA)

Invited Speaker:
Brad Seibel (University of Rhode Island, USA)

Studies exploring the effects of ocean acidification on zooplankton are scarce, and with few exceptions are limited to assessing direct effects on zooplankton calcification. This focus on calcification, although vitally important, constrains our ability to predict what effects ocean acidification will have on zooplankton in a wider biological and ecological context. For example, what are other direct, but sub-acute zooplankton responses to ocean acidification? How might these responses alter zooplankton interactions with their predators and prey? What may be the effects on zooplankton-mediated nutrient cycling? Will the timing of transition between zooplankton life histories be altered by ocean acidification? How might secondary production change in response to acidification? Will the magnitude of these effects be altered by interactions with climate parameters synergistic with ocean acidification? This workshop solicits participation from plankton biologists and ecologists that wish to contribute to a dialog aimed at meeting these specific workshop goals: (1) report on current research and/or discoveries regarding zooplankton and ocean acidification, and (2) identify the critical research and information needed to provide a framework for better predicting zooplankton responses to ocean acidification.

8:30 ***Introduction by Convenors***

8:35 **Brad A. Seibel (Invited)**
Zooplankton physiology in a changing ocean: Synergistic effects of climate-related variables on metabolism (W4-7106)

9:00 **M. Brady Olson, Brooke A. Love and Suzanne L. Strom**
Microzooplankton feeding and growth in an acidified ocean (W4-6895)

9:20 **Barbara Niehoff, Jan Czerny, Signe Klavsen, Sebastian Krug and Kai Schulz**
The response of zooplankton to elevated CO_2 concentrations: Results from a mesocosm experiment in a high Arctic fjord (W4-7280)

9:40 **Jörg Dutz, Sara Ceballos, Alejandro Isla and Erik Selander**
Does the allelopathic and toxic activity of *Alexandrium minutum* change with ocean acidification? (W4-7036)

10:00 ***Coffee/Tea Break***

10:30 **Maria Byrne, Steve Doo, Natalie Soars and Symon Sworjanyn**
Effects of ocean warming and acidification on larval development in the diadematoid sea urchin *Centrostephanus rodgersii* (W4-7329)

10:50 **So Kawaguchi, Haruko Kurihara, Rob King, Akio Ishida, Masahide Wakita, Lillian Hale, Thomas Berli, James P. Robinson, Stephen Nicol, Patti Virtue and Atsushi Ishimatsu**
Impacts of Ocean Acidification on early development of Antarctic krill (W4-7000)

11:10 **James P. Robinson, So Kawaguchi, Atsushi Ishimatsu, Haruko Kurihara, Rob King, Patti Virtue and Stephen Nicol**
The effects of CO_2-induced ocean acidification on the survival and development of early larval stage Antarctic krill (*Euphausia superba*) (W4-7187)

11:30 **Leah R. Feinberg, Melissa E. Prechtl and William T. Peterson**
Impacts of ocean acidification on the hatching success and larval development of *Euphausia pacifica* (W4-7079)

11:50 **Liza M. Roger, A. David McKinnon, Anthony J. Richardson and Brenton Knott**
Comparison of shell structure of two tropical species of thecosome pteropods (*Creseis acria* and *Diacavolinia longirostris*) over a 40-year period (W4-6926)

12:10 Discussion

12:30 Workshop ends

Posters

W4-7111 **Moira Galbraith and David L. Mackas**
Pteropod time series from the NE Pacific

W4-7131 **Cathryn Wynn-Edwards, Andrew Davidson, Simon Wright, So Kawaguchi, Rob King, Peter Nichols and Patti Virtue**
Effects of elevated CO_2 levels on the biochemical composition of Antarctic phytoplankton species and their quality as food for *Euphausia superba* larvae

W4-7181 **Kristian McConville, Elaine Fileman and Claudia Halsband-Lenk**
Impact of ocean acidification on the reproduction of coastal calanoid copepods

W4-7188 **James P. Robinson, So Kawaguchi, Atsushi Ishimatsu, Haruko Kurihara, Rob King, Patti Virtue and Stephen Nicol**
The effects of CO_2-induced ocean acidification on the survival and development of early larval stage Antarctic krill (*Euphausia superba*)

March 16

Workshop 5 (W5)

Automated visual plankton identification

Co-Convenors:
Mark Benfield (LSU, USA)
Phil Culverhouse (Plymouth University, UK)

Invited Speaker:
Cabell Davis (Woods Hole Oceanographic Institution, USA)

Advanced pattern recognition techniques are being applied to plankton identification to automate sample specimen counting to generic level. These tools, for example Zoo/Phyto Image and Zooprocess/Plankton Identify offer fast semi-automatic identification. They are free and can analyse the output from a flatbed scanner (Zoo/phyto Image), Zooscan and FlowCAM instruments as well as from digital cameras and other sources. This workshop will introduce the concepts and methods used, with some practical experience in using the tools. Automation can allow many thousands of specimens to be analysed daily. This workshop is a must for those wishing to embrace this new technology.

The workshop is split into 4 blocks. The first block will present an overview of current practices (manual and machine), together with the shortcomings of manual identification (if you have a laptop, you can take part in an identification experiment). We then introduce the basics of machine identification (i.e., extracting measurements from plankton images and using spreadsheets to show how images may be grouped into clusters), using previously prepared data from a Zooimage or a Zooscan machine. The third block will cover issues of machine calibration and using it in routine sample analysis. We will close with a look what is happening in leading laboratories around the world, and what the future holds.

8:30	***Introduction by Convenors***
8:35	**Cabell Davis (Invited)** In situ optical imaging of mesoplankton using the Video Plankton Recorder and digital holographic imaging (W5-7254)
9:00	**Lars Stemmann, Franck Prejger, Corinne Desnos, Marc Picheral and Gabriel Gorsky** Long term and spatial plankton monitoring with the ZooScan: Insights from a 6 years project at the Laboratory of Villefranche sur Mer and perspectives for a global network (W5-7009)
9:15	**Elvire Antajan,Stéphanie Lelièvre and Sandrine Vaz** Comparison of winter fish eggs distribution in Eastern Channel and Southern North Sea derived from traditional microscopy and digitalized images analysis identification (W5-7192)
9:30	**Harry Nelson, Ben Spaulding and Matthew Duplisea** New methods for using a continuous imaging particle analyzer (FlowCAM) for the analysis and classification of zooplankton (W5-7223)
9:45	**Catarina R. Marcolin and Rubens M. Lopes** Zooplankton biomass size spectra off Rio de Janeiro (Brazil) estimated by LOPC and Zooscan observations (W5-7334)
10:00	***Coffee/Tea Break***
10:30	Discussion
12:30	Workshop ends

Posters

W5-7149 **Xiaoxia Sun, Song Sun, and Shiwei Wang**
Application of automated image identification in the Jiaozhou Bay zooplankton ecological study

W5-7186 **Karen Manríquez, Nicolás Bralic and Rubén Escribano**
Biomass structure of the mesozooplankton in the coastal upwelling system off central-southern Chile during the spring 2004 as assessed by automated image analysis

March 16

Session 4 (S4)

Small-scale biological-chemical-physical interactions in the plankton

Convenor:
David Fields (Bigelow Laboratory for Ocean Sciences, USA)

Invited Speaker:
John Dower (University of Victoria, BC, Canada)

Processes that occur at the level of the individual animal drive large scale distribution patterns of zooplankton populations. At the scale of the individual, motility, feeding rates, detection of signals, and encounter rates with other individuals are the product of the interactions between the individual and physical properties of their environment (*e.g.* viscosity, fluid motion, diffusion). Research on this topic is inherently interdisciplinary. It includes fluid dynamics across the viscous-inertial ranges, the study of functional morphology and structural analysis, investigations into the sensory perception of both mechanical and chemical cues, and much more. In this session, we invite contributions that explore the intimate interactions of zooplankton with their prey, predators, conspecifics, and their environment, framed within the context of large-scale distribution patterns of zooplankton.

14:00	***Introduction by Convenors***
14:05	**John F. Dower and Pierre Pepin (Invited)** Does individual variability matter in small-scale interactions involving zooplankton? Observations and considerations from ichthyoplankton field studies (S4-7208)
14:30	**Margarita Zarubin, Viviana Farstey and Amatzia Genin** Depth keeping by swimming against the flow in zooplankton: Adaptive benefits and ecological implications (S4-6956)
14:50	**David M. Fields, T. Quincy Browne and Steve D. Shema** Mechanoreceptive hairs: How do they work? (S4-7172)
15:10	**Houshuo Jiang, Thomas Kiørboe and Sean P. Colin** Toward a mechanistic understanding of the jumping behavior of copepods (S4-7114)
15:30	**Luis Fabiano Baldasso, J. Rudi Strickler and Rubens M. Lopes** Behavioral responses of *Temora turbinata* (Copepoda, Calanoida) exposed to phytoplankton thin layers (S4-7333)
15:50	***Coffee/Tea Break***
16:20	**Susanne Menden-Deuer** Predator prey interactions in the plankton: Linking microscopic behaviors to population dynamics (S4-7206)
16:40	**Fred Marin and Cabell Davis** Quantification of plankton and marine snow in the Gulf of Mexico during summer 2010 using the Video Plankton Recorder (S4-7298)
17:00	Session ends

Posters

S4-6996 **Zorka Dulić, Miloš Ćirić, Nada Lakić, Marko Stanković, Božidar Rašković and Katarina Bjelanović**
Effects of water source change on zooplankton in aquaculture ponds

S4-7141 **Adriana V. Araujo, Cristina de O. Dias and Sérgio L.C. Bonecker**
Copepod assemblage dynamics in a tropical estuary

S4-7178 **Joshua J. Ziarek, Ai Nihongi, Takeyoshi Nagai, Marco Uttieri and J. Rudi Strickler**
Seasonal adaptations of *Daphnia pulicaria* swimming behaviour: The effect of water temperature

S4-7209 **M. Clara Menéndez, M. Sofía Dutto, Florencia Biancalana, M. Cintia Piccolo and Mónica S. Hoffmeyer**
Tidal and seasonal changes in the mesozooplankton community in a highly turbid and mixed estuary (Bahía Blanca, Argentina)

March 16-17

Session 5 (S5)

Zooplankton in upwelling and coastal systems

Convenors:
Jenny Huggett (Ocean and Coastal Management, South Africa)
Julie Keister (University of Washington, USA)

Invited Speaker:
Rubén Escribano (COPAS, Universidad de Concepción, Chile)

Upwelling and coastal ecosystems exhibit high temporal and spatial variability in their physical and biological structure, are extremely productive, and are important to global fisheries and biogeochemical cycles. The zooplankton which inhabit these systems are diverse, exhibit a variety of life history strategies and physiological adaptations, and are integral to trophic functioning. In coastal upwelling systems in particular, zooplankton are exposed to strong alongshore and across-shelf circulation and physical gradients which structure their distributions. In addition, coastal regions are under increasing pressure from climate and human impacts that may lead to shifts in species composition, dominance, and distribution. In this session we will examine the behaviors, physiology, community structure, and spatial and temporal patterns of zooplankton in coastal ecosystems. Field, laboratory, and modeling studies will be considered, with an emphasis on studies that elucidate mechanisms of zooplankton variability in these highly dynamic regions.

March 16

14:00	***Introduction by Convenors***
14:05	**Rubén Escribano (Invited)** Zooplankton in upwelling and coastal systems (S5-7489)
14:30	**Claudia Halsband-Lenk, Stefano Ciavatta and Claire Widdicombe** Long-term and interannual variability of zooplankton at a coastal station in the Western English Channel (S5-7198)
14:50	**Song Sun, Shiwei Wang, Chaolun Li and Xiaoxia Sun** The life history strategies of *Calanus sinicus* in the continental shelf ecosystem (S5-7154)
15:10	**Michael Ballón, Arnaud Bertrand, Anne Lebourges-Dhaussy, Mariano Gutiérrez, Patricia Ayón, Daniel Grados and François Gerlotto** Is there enough zooplankton to feed forage fish population off Peru? An acoustic (positive) answer (S5-7102)
15:30	**Stephen Romaine and Moira Galbraith** The presence of distinct offshore planktonic communities in coastal British Columbia inlets (S5-6985)
15:50	***Coffee/Tea Break***
16:20	**Rana W. El-Sabaawi, Marc Trudel, David L. Mackas, John F. Dower and Asit Mazumder** Interannual variability in nitrogen dynamics and zooplankton structure in the northern range of the California upwelling system (S5-7151)
16:40	**Jesse F. Lamb and William T. Peterson** Comparing the hydrography and copepod community structure of the continental shelf ecosystems of Washington and Oregon, USA from 1998 to 2009: Can a single transect serve as an index of ocean conditions over a broader area? (S5-6892)

17:00 **Katia Aronés, Luis Vásquez, Alexis Chaigneau and Patricia Ayón**
Variability of the zooplankton community in the Northern Humboldt Current System (2007-2009) and its relation to physical forcing (S5-7174)

17:20 **Antonina dos Santos, Carla Santinho, A. Miguel P. Santos and Margarida Castro**
Abundance and mortality of the larvae of the green crab *Carcinus maenas* in the Bay of Cascais, northeastern Atlantic (S5-7010)

17:40 **Anja Kreiner and Dawit Yemane**
Variability in copepod communities in the northern Benguela upwelling region from 2000 to 2010 (S5-7235)

18:00 Session ends

March 17

8:30 ***Introduction by Convenors***

8:40 **Hans-Juergen Hirche, Kristina Barz, Patricia Ayón, Jan Schulz and Andree Luedtke**
Zooplankton in the southeast Pacific upwelling: Diversity and vertical distribution derived from an optical imaging system and automated image analysis (S5-6931)

9:00 **Arnaud Bertrand, Michael Ballón, Alexis Chaigneau, Daniel Grados, Zaida Quiroz, Patricia Ayón, Florian Monetti and Ronan Fablet**
High resolution of macrozooplankton biomass distribution in relation to the depth of the upper oxygen minimum zone off Peru (S5-7038)

9:20 **C. Tracy Shaw, Leah R. Feinberg and William T. Peterson**
Population dynamics of the euphausiids *Euphausia pacifica* and *Thysanoessa spinifera* in the upwelling region off Newport, OR, USA (S5-7129)

9:40 **Jason D. Everett, Mark E. Baird, Natasha Henschke, Kylie A. Pitt and Iain M. Suthers**
Swarms of the salp *Thalia democratica* off south-eastern Australia: The interaction of oceanography, fecundity and growth (S5-7222)

10:00 ***Coffee/Tea Break***

10:30 **Ricardo Giesecke, Humberto E. González and Rubén Escribano**
The role of chaetognaths in trophic carbon cycling in the central-southern Humboldt Current System off Chile (S5-7099)

10:50 **Mary Mar P. Noblezada and Wilfredo L. Campos**
Comparison of chaetognath assemblages along the Pacific Coast and adjacent inland waters of the Philippines: Biological indicators of water mass movement (S5-6927)

11:10 **Jonathan Correa, Alexis Chaigneau, Carmen Grados and Patricia Ayón**
Vertical structure of copepods in the Northern Humboldt Current System (6°-8°S) during February 2008 (S5-7216)

11:30 **Odette Vergara, Rubén Escribano and Valentina Valdés**
Is zooplankton grazing an important pathway of C through the pelagic food web in a highly productive coastal unwilling system?
(S5-7109)

11:50 **Joana Cruz, M. Alexandra Chícharo, Radhouane Ben-Hamadou, Luís Chícharo, Pedro Ré and A. Miguel P. Santos**
Characterization of plankton communities and *Acartia* reproductive traits related to environmental conditions in the Guadiana river estuary and adjacent coastal zone (S5-7158)

12:10 **Lidia Yebra, Sébastien Putzeys, Dolores Cortés, Francisco Gómez, Pablo I. León, Jesús Mercado and Soluna Salles**
Effect of summer eutrophication on the coastal zooplankton community composition along the Iberian Alborán Sea (SW Mediterranean) (S5-6878)

12:30 Session ends

Posters

S5-6431 **Malihe Sanjarani and Elahe Sanjarani**
Trends in the distribution and diversity of tintinnids in Iranian waters of the Oman Sea

S5-6911 **Leonardo Kenji Miyashita**
Production of *Penilia avirostris* (Cladocera, Ctenopoda) off Ubatuba, Brazil

S5-6920 **Pamela Hidalgo, Rubén Escribano, Odette Vergara, Ramiro Riquelme-Bugueño and Pamela Pino**
Zooplankton biomass and production in the coastal upwelling zone off the Chilean Humboldt Current System

S5-6969 **Georgina Cepeda, Daniel Hernández and María Delia Viñas**
Oithona nana: population dynamics at the EPEA coastal station (38º28´S 57º41´W) and at the Rio de la Plata estuarine front

S5-6972 **Cécile Roques, Nicole Lautredou-Audouy, Séverine Boyer and Delphine Bonnet**
Monitoring ciliate populations in Thau lagoon (South of France)

S5-6977 **Mariela L. Spinelli, Marcelo Pájaro, Patricia Martos, Graciela B. Esnal and Fabiana L. Capitanio**
Size fractions of mesozooplankton (Copepoda and Appendicularia) in relation to first feeding larvae of anchovy (*Engraulis anchoita*) during spring of 2004 at the frontal system of Peninsula Valdes (42-44ºS), Argentina

S5-6998* **Anna Dubinina, Natalya Buslova and Oleg Tepnin**
(*Presenter: colleague on behalf of Anna Dubinina*)
Spring zoo- and ichthyoplankton of the Pacific Ocean waters adjacent to Kamchatka in 2006-2007

S5-7031 **María Delia Viñas, Rubén Negri, Ricardo Silva, Fabiana L. Capitanio, Cristina Daponte and Daniel Hernández**
Zooplankton structure and succession at the EPEA coastal station (northern Argentina): Dominance of the smaller size fractions

S5-7058* **M. Sofía Dutto, M. Celeste López Abbate, Florencia Biancalana, Anabela A. Berasategui and Mónica S. Hoffmeyer**
(*Presenter: Anabela A. Berasategui on behalf of M. Sofía Dutto*)
Does untreated sewage discharge affect the zooplankton community? A case study in a turbid estuary (Bahía Blanca, Argentina)

S5-7059 **Arasan Srinivasan and Rajdeep Dutta**
Seasonal distribution and biomass of copepods in the Thoothukudi coastal waters of the Gulf of Mannar, southeast coast of India

S5-7083 **Sarah Pausina, Emily Saeck, Felipe Gusmão, A. David McKinnon and Anthony J. Richardson**
Zooplankton community response to disturbance following a flood event in a subtropical bay, Australia

S5-7094 **Tatiana R. Avila, Anderson Abel S. Machado and Adalto Bianchini**
Estimation of secondary production in Patos Lagoon Estuary (Brazil): Methodological aspects

S5-7098 **MªLuz Fernández de Puelles, Laura Vicente and Alicia Herrera**
Comparative studies on zooplankton (micro- and mesozooplankton) in two oligotrophic areas of the Central Western Mediterranean

S5-7108 **Bellineth Valencia, Bertha Lavaniegos and Alan Giraldo**
Temporal and spatial variation of hyperiid amphipod assemblages in the eastern tropical pacific off Colombia (2007-2008)

S5-7139 **Arturo Nava-Torales, Sergio Hernández-Trujillo and Gabriela Ma. Esqueda-Escárcega**
Mesozooplankton community structure in Bahía de La Paz, Mexico

S5-7147 **Jay O. Peterson, William T. Peterson and Cheryl A. Morgan**
Seasonal and inter-annual variability in copepod species composition and egg production related to climate and upwelling dynamics in the northern California Current.

S5-7155 **Noyan Yilmaz and Ahsen Yuksek**
Climate, hydrography and invasive species driven decadal variability in zooplankton of the highly stratified Sea of Marmara

S5-7164 **Manuela Pérez-Aragón, Camila Fernández and Rubén Escribano**
Nitrogen excretion by mesozooplankton in a coastal upwelling area: Seasonal comparison and implications for biological production

S5-7195* **Xanthippi Geraki, Dimitris Christodoulou, George Papatheodorou and Nina Fragopoulu**
(*Presenter: Ioanna Siokou on behalf of Xanthippi Geraki*)
Zooplankton in a groundwater formatted pockmark field (Eastern Mediterranean)

S5-7247 **Per B. Holliland, Ida Ahlbeck, Erica Westlund and Sture Hansson**
Ontogenetic and seasonal changes in diel vertical migration amplitude of the calanoid copepods *Eurytemora affinis* and *Acartia* spp. in a coastal area of the northern Baltic Proper

S5-7249 **Jean Blanchot, Gisèle Champalbert, Marc Pagano, LoMartine Rodier and Robert Arfi**
Tidal effects on the zooplankton composition and abundance in a coral reef lagoon (Toliara, Madagascar)

S5-7263 **María Muñoz, Andreas Reul, Begoña Bautista, José M. Blanco, Jaime Rodríguez, José A. Fernandes, Pablo I. León and Valeriano Rodríguez**
Spatial structure and diel changes of the zooplankton community along the Garrucha canyon (SW-Spain) as derived from dissecting microscope, ZooImage, and FlowCAM analysis

S5-7272 Sonia **Yáñez, Paula Ruz, Rubén Escribano and Pamela Hidalgo**
How copepod growth may respond to distinct upwelling regimes?

S5-7273 **Sergio Hernández-Trujillo, Gabriela Ma. Esqueda-Escárcega and Ma. del Rocío Pacheco-Chávez**
Temporal variability of copepod community in the Bahía de La Paz, México

S5-7282* **Augusto César Crespi Abril, Pedro José Barón and Enrique Mario Morsan**
(*Presenter: Pedro José Barón on behalf of Augusto César Crespi Abril*)
Seawater temperature, α-chlorophyll and zooplankton samples support a new paradigm: Coastal waters off northern Patagonia play a major role as spawning and nursery areas for early life-cycle planktonic stages of the Argentine squid *Illex argentinus*

S5-7295* **Carmela Nakazaki, Katia Aronés and Patricia Ayón**
(*Presenter: Co-Authors on behalf of Carmela Nakazaki*)
Planktonic amphipods distribution in upwelling zones in northern Humboldt Current System

S5-7303 **Roberto Quesquén and Patricia Ayón**
Key copepods in a coastal upwelling area in the Northern Humboldt Current System

S5-7304 **Luciana Pinto Sartori and Rubens M. Lopes**
Zooplankton size spectra obtained by LOPC from Abrolhos Bank

S5-7306 **Paula Ruz, Sonia Yáñez, Daniela Araya, Pamela Hidalgo and Rubén Escribano**
Production of copepods upon a nearly-continuous coastal upwelling regime in the northern Humboldt Current system off Chile

S5-7315 **Beatriz Yannicelli, Kurt Paschke, Rodrigo Gonzalez and Leonardo Castro**
Metabolic responses of *Pleuroncodes monodon* larvae to low oxygen concentration

March 17

Session 7 (S7)

Zooplankton physiology and bioenergetics

Convenors:
Andrew Hirst (Queen Mary University of London, UK)
Maria Koski (National Institute of Aquatic Resources, Technical University of Denmark)

Invited Speaker:
Robert Campbell (University of Rhode Island, USA)

The physiological and bioenergetics of zooplankton are central to nutrient recycling, food-web transfer efficiency and biogeochemical transformations (such as the modification of sinking flux) in the world oceans. If we are to understand and model biogeochemical processes across a range of scales, we need to continue to refine our understanding of the transformations which zooplankton make. Further, physiology and bioenergetics are closely allied to a species fitness, and hence species success. This session aims to describe zooplankton physiology, to present frameworks on what shapes these rates, and our ability to improve their prediction. We expect to provide insights into the effects of physiological adaptations on individual fitness, food-web processes and global biogeochemical cycles, including considerations of changing environmental conditions.

8:30	***Introduction by Convenors***
8:35	**Robert G. Campbell (Invited)** The physiology, bioenergetics, and life history traits of *Calanus* species in Arctic and Subarctic seas (S7-7073)
9:00	**Delphine Bonnet, Carmen García-Comas and Roger P. Harris** Does fit mean productive? (S7-6935)
9:20	**Christine J. Cass and Kendra L. Daly** Effects of temperature and oxygen on metabolic parameters for eucalanoid copepods of the eastern tropical north Pacific: Implications for biogeochemical cycles (S7-7224)
9:40	**Ramiro Riquelme-Bugueño, Jaime Gómez-Gutiérrez, Jennifer Menkel, Leah R. Feinberg, William T. Peterson and Rubén Escribano** Health condition and body growth rates of euphausiids of the California and Humboldt Current Systems and the Gulf of California using the hepato-somatic index (S7-7276)
10:00	***Coffee/Tea Break***
10:30	**Jennifer Menkel, William T. Peterson and Ramiro Riquelme-Bugueño** Krill physiological condition and growth in relation to changing environmental conditions in the Northern California Current, USA (2007-2010): *Euphausia pacifica* and *Thysanoessa spinifera* (S7-7143)
10:50	**Kazutaka Takahashi, Keiichiro Ide, Kazuya Yoshimura, Akira Kuwata, Hiroaki Saito and Takeo Hama** Effect of spring diatom bloom on reproductive activity, egg production and hatching success of *Eucalanus bungii* in the Oyashio region, western subarctic Pacific (S7-7324)
11:10	**Juan Bueno and Ángel López-Urrutia** A unifying theory of metabolic scaling and life history evolution for developmental time (S7-7212)

11:30 **Peter Thor and Ida Wendt**
Functional response of carbon absorption efficiency in the calanoid copepod *Acartia tonsa* (S7-7332)

11:50 **Elena Gorokhova, Lisa Mattsson, Rehab El-Shehawy, Claire Holeton, Hedvig Hogfors, Towe Holmborn, Anu Vehmaa, Andreas Brutemark and Jonna Engström-Öst**
Oxidative stress and antioxidant responses in copepods: Effects of food quantity and quality (S7-7316)

12:10 **Lutz Postel**
Productivity of mesozooplankton: Scaling of aspartate transcarbamylase activity (ATC) measurements by allometric model calculations (S7-6971)

12:30 Session ends

Posters

S7-6881 **Stamatina Isari and Enric Saiz**
Feeding performance of the copepod *Clausocalanus lividus* (Frost and Fleminger, 1968)

S7-6882 **Lidia Yebra, Elisa Berdalet, Rodrigo Almeda, Verónica Pérez, Albert Calbet and Enric Saiz**
Protein and nucleic acid metabolism as proxies for growth and fitness of *Oithona davisae* early developmental stages

S7-6894 **Toru Kobari, Shigeki Kori and Haruko Mori**
Nucleic acids and protein contents as proxies for protein-specific growth of *Artemia salina*

S7-6903 **May Gómez, Igor Fernández-Urruzola, Alicia Herrera, F. Maldonado, I. Martínez, Natalia Osma and Ted T. Packard**
The R/ETS ratio: Where we are now

S7-6906 **May Gómez, I. Martínez, I. Mayo, J.M. Morales and Ted T. Packard**
Zooplankton secondary production models in cultures of *Daphnia magna*: A comparison study

S7-6907 **Victor Aguilera-Ramos, Rubén Escribano, Katty Donoso, Serge Poulet and José Martínez**
Experimental evidence that sustained and environmentally realistic diatoms bloom conditions may lead to a decrease in the reproductive fitness of copepods

S7-6916* **Daniel J. Mayor, Kathryn Cook, Barry Thornton, Pamela Walsham, Ursula F.M. Witte, Alain F. Zuur and Thomas R. Anderson**
(*Presenter: Sari Giering on behalf of Daniel J. Mayor*)
Absorption efficiencies and basal turnover of carbon, nitrogen and fatty acids in *Calanus* spp.

S7-6939 **Alicia Herrera-Ulibarri, May Gómez and Ted T. Packard**
The effect of starvation on respiratory metabolism in *Leptomysis lingvura*

S7-6953 **Fabien Lombard, Laurent Labeyrie, Elisabeth Michel, Laurent Bopp, Elsa Cortijo, Sophie Retailleau, Helene Howa and Frans Jorissen**
Reproducing planktic foraminiferan growth, habitat and abundance using an ecophysiological multispecific approach

S7-7011 **Sara Zamora and Enric Saiz**
Reproductive performance of *Oithona davisae* (Copepoda, Cyclopoida) feeding on different concentrations of the heterotrophic dinoflagellate *Oxyrrhis marina*

S7-7020 **Marja Koski and Sigrun Jónasdóttir**
Critical stages of nauplii growth: Is the early development determined by maternal reserves or initial feeding?

S7-7097 **Jörg Dutz, J.E.E. van Beusekom and R. Hinrichs**
Factors controlling the seasonal dynamics of fecundity and recruitment of *Temora longicornis* in the Baltic Sea

S7-7117* **Federico Maldonado Uribe, Ted T. Packard and May Gómez**
(*Presenter: Ted T. Packard on behalf of Federico Maldonado Uribe*)
Absence of substrates underestimates the measurement of electron transport system activity in zooplankton

S7-7132* **Igor Fernández-Urruzola, May Gómez and Ted T. Packard**
(*Presenter: Ted T. Packard on behalf of Igor Fernández-Urruzola*)
The impact of body size and starvation on the biochemistry and the physiology of ammonium excretion in the mysid *Leptomysis lingvura*

S7-7133* **Natalia Osma, Ted T. Packard and May Gómez**
(*Presenter: Ted T. Packard on behalf of Natalia Osma*)
Role of pyridine nucleotides in controlling the respiration of the dinoflagellate *Oxyrrhis marina*

S7-7163* **Rodrigo Almeda, Enric Saiz, Miquel Alcaraz, Albert Calbet and Lidia Yebra**
(*Presenter: Enric Saiz on behalf of Rodrigo Almeda*)
Ecophysiology of the naupliar stages of the cyclopoid copepod *Oithona davisae*

S7-7179 **Claudia Castellani and Yener Altunbaş**
Seasonal acclimatisation of the respiration rate of *Temora longicornis* (Müller)

S7-7242 **Roswati Md Amin, Marja Koski and Ulf Båmstedt**
Species and strain- specific effect of *Skeletonema marinoi* on copepod physiology

S7-7279 **Lars J. Hansson**
Mnemiopsis leidyi feeding response to temperature is size dependent

S7-7286 **Stephanie L. Bush**
Physiological ecology of the diel vertically migrating squid *Pterygioteuthis* sp.

S7-7289 **Susana Garrido, Joana Cruz and Chiara Coniglione**
Effect of temperature, food type and concentration on the grazing and reproduction of the calanoid copepod *Centropages chierchiae*

March 18

Session 8 (S8)

The role of zooplankton in biogeochemical cycles

Convenors:
Hiroaki Saito (Tohoku National Fisheries Research Institute, Japan)
Deborah Steinberg (Virginia Institute of Marine Science, USA)

Invited Speaker:
Santiago Hernandez-Leon (Universidad de Las Palmas de GC, Spain)

Zooplankton play an integral role in the cycling of elements in the sea. As key drivers of the biological pump, zooplankton feed in surface waters and produce sinking fecal pellets, and actively transport dissolved and particulate matter to depth via vertical migration. Zooplankton grazing and metabolism transforms particulate organic matter into dissolved forms, affecting primary producer populations, microbial remineralization, and particle export to the ocean's interior. The elemental stoichiometry of zooplankton and their prey often differ, resulting in non-Redfield cycling of C, N and P. We invite papers on role of zooplankton (both metazoan and protozoan) in biogeochemical cycles reflecting the significant strides that have been made in this area, as well as identifying crucial gaps in our knowledge. Topics may include, but are not limited to: the role of zooplankton in the biological pump, mesopelagic and deep sea processes, trophic interactions and nutrient cycling, ecological stoichiometry, effects on biogeochemical cycling (measured or modeled) of human or climate influenced changes in zooplankton community structure, and regional comparisons or global syntheses of the importance of zooplankton in biogeochemical cycles. This session theme is closely related to research goals within IMBER (Integrated Marine Biogeochemistry and Ecosystem Research).

8:30	***Introduction by Convenors***
8:35	**Santiago Hernández-León (Invited)** Zooplankton and biogeochemical cycles: Who is conducting the orchestra? (S8-7318)
9:00	**Houssem E. Smati, Songniang Jiang, Maureen H. Conte and Tommy D. Dickey** Physical forcing, zooplankton dynamics and particulate carbon export to the deep ocean in the northwestern Sargasso Sea (S8-6890)
9:20	**Jillian L. Schneider, Leanne Elder, Rui Rosa, Amy Maas, Lillian Hancock and Brad A. Seibel** Hypoxia induced metabolic suppression in migratory zooplankton living in oxygen minimum zones (S8-7162)
9:40	**Sari L.C. Giering, Richard Sanders, Richard S. Lampitt, Chris Marsay and Daniel J. Mayor** Mesozooplankton demands exceed carbon flux in the twilight zone (S8-6992)
10:00	***Coffee/Tea Break***
10:30	**Marja Koski, Kristine Engel Arendt, Fabien Lombard, Sigrun Jónasdóttir, Jörg Dutz and Sanne Kjellerup** Copepods and the biological pump: The potential effects of large *vs.* small copepods on vertical flux (S8-7019)
10:50	**Christian Wexels Riser, Camilla Svensen, Marit Reigstad, Lena Seuthe and Tobias Tamelander** Degradation of copepod faecal pellets: The role of small-sized, <180µm, plankton and *Calanus finmarchicus* (S8-7215)

11:10 **Fabien Lombard and Thomas Kiørboe**
Marine snow originating from appendicularia: Age-changes in houses settling characteristics and the effect of ballast material (S8-6952)

11:30 **Hiroaki Saito**
Geochemical biogeography: Bridging the gap between zooplanktology and biogeochemistry (S8-6949)

11:50 **Gérald Darnis and Louis Fortier**
Zooplankton mediation of carbon cycling and export in the Amundsen Gulf system (southeastern Beaufort Sea) (S8-7226)

12:10 **Julie E. Keister and Stephen D. Pierce**
The impact of upwelling filaments on carbon cycling and advection of coastal zooplankton: A synthesis with new observations (S8-7311)

12:30 Session ends

Posters

S8-6905 **Ted T. Packard and May Gómez**
Zooplankton respiration and vertical carbon flux

S8-6915 **Toru Kobari, Minoru Kitamura, Masato Minowa, Hiroshi Isami, Hiroyasu Akamatsu, Hajime Kawakami, Kazuhiko Matsumoto and Makio C. Honda**
Comparison of depth distribution of mesozooplankton communities between the subarctic and subtropical Pacific Oceans: Relative importance of vertical migrants to downward carbon flux

S8-6919 **Hiroshi Isami, Minoru Kitamura, Masato Minowa, Toru Kobari, Hiroyasu Akamatsu, Hajime Kawakami, Kazuhiko Matsumoto and Makio C. Honda**
Relative importance of respiratory carbon flux by *Pleuromamma* copepods in the subarctic and subtropical Pacific Oceans

S8-6921 **A. David McKinnon, Felipe Gusmão, Miles Furnas and Ruth Böttger-Schnack**
The contribution of metazooplankton to carbon flux in waters adjacent to an eastern Indian Ocean coral atoll

S8-7039 **Cristian A. Vargas, Paulina Y. Contreras, Alejandra Lafon, Nelson Silva and Rodrigo A. Martínez**
How significant are allochthonous subsidies for zooplankton production in coastal areas?

S8-7045 **Gara Franchy and Santiago Hernández-León**
A simple model to estimate active flux in relation to zooplankton lunar cycles in subtropical waters

S8-7052* **Florencia Biancalana, M. Sofía Dutto, Germán A. Kopprio, Rubén J. Lara and Mónica S. Hoffmeyer**
(*Presenter: Anabela Berasategui on behalf of M. Sofía Dutto*)
Variation in nitrogen and carbon isotopes in the Bahía Blanca Estuary: Implications for ecological studies in a human-disturbed system

S8-7060 **Alejandro V. Ariza, Natacha Aguilar and Santiago Hernández-León**
Daily ration and feeding chronology of dominant diel vertical migrant fishes in the Subtropical Eastern North Atlantic Ocean

S8-7078* **Sébastien Putzeys, Lidia Yebra, Carlos Almeida, Pierrick Bécognée and Santiago Hernández-León**
(*Presenter: Lidia Yebra on behalf of Sébastien Putzeys*)
Influence of the late winter bloom on migrant zooplankton metabolism and its implication for export flux

S8-7096 **MªLuz Fernández de Puelles, Alejandro Isla, Renate Scharek, Mikel Latasa Antonio Bode and Sandra Gregorés**
Changes in zooplankton population structure during and after the north-western Mediterranean open sea spring bloom

S8-7113 **Felipe Gusmão, Joanna Strzelecki and A. David McKinnon**
Mesozooplankton growth as measured by enzymatic activity off the Western Australia coast

S8-7156 **Catherine Lalande, Eduard Bauerfeind, Eva-Maria Nöthig, Michael Klages and Antje Boetius**
Zooplankton fecal pellet export during spring in the eastern Fram Strait

S8-7211* **Mario Lebrato, Andreas Oschlies, Markus Pahlow, Juan Carlos Molinero, Kylie A. Pitt, Andrew K. Sweetman, Daniel O.B. Jones and Robert H. Condon**
(*Presenter: Juan Carlos Molinero on behalf of Mario Lebrato*)
Depth attenuation of organic matter export associated with jelly-falls

S8-7248 **I. Herrera-Rivero, Gara Franchy, Alejandro V. Ariza, Lidia Yebra and Santiago Hernández-León**
Zooplankton biomass and indices of grazing, metabolism and growth after a dust deposition event in subtropical waters

S8-7261 **Isabelle Rombouts and Grégory Beaugrand**
A global approach linking climate and marine copepod diversity to ecosystem functioning

S8-7302 **Maarten Boersma, Arne M. Malzahn, Katherina L. Schoo and Karen H. Wiltshire**
Ecological stoichiometry and trophic interactions: The role and fate of nutrients

March 18

Session 9 (S9)

The diverse role of meroplankton in the biology and ecology of marine systems

Convenors:
Claudio DiBacco (Bedford Institute of Oceanography, Fisheries and Oceans Canada)
Heidi L. Fuchs (Institute of Marine and Coastal Sciences, Rutgers University, USA)
Fabian Tapia (Centro FONDAP-COPAS, Universidad de Concepción, Chile)

Invited Speaker:
Jesús Pineda (Woods Hole Oceanographic Institution, USA)

Meroplankton are transient members of the plankton and crucial to the establishment and sustainability of marine communities. Local and global marine stressors (e.g., habitat destruction, resource over-harvesting, contaminant loading, climate change, introduction of non-native species) will impact some species in diverse ways as individuals move through both planktonic and benthic life stages. It is thus imperative to develop a better understanding of larval processes at all functional levels, from species to ecosystems. In this session, we welcome submissions on all meroplankton-related topics, including but not limited to larval behaviour and sensory ecology, dispersal and connectivity, invasions and fisheries, design of marine reserves and effects of climate change on larval processes.

8:30 ***Introduction by Convenors***

8:35 **Jesús Pineda, Brian L. White and Victoria S. Starczak (Invited)**
Species rarity in mangrove coastal lagoons: Timing of spawning, larval transport and settlement (S9-7152)

9:00 **Dafne Eerkes-Medrano, Lorenzo Ciannelli, Angela Johnson, Chris Langdon, Christine Sislak and Bruce Menge**
Effects of nearshore hypoxia on invertebrate meroplankton of the Oregon coast (S9-7081)

9:20 **Lu Guan, John F. Dower and Skip McKinnell**
Quantifying mesoscale patterns of spatiotemporal variability of four temperate larval fish species on Canada’s west coast (S9-6943)

9:40 **Pennie Lindeque, Elaine Fileman and Claudia Halsband-Lenk**
Meat and two veg? Determining feeding selectivity of bivalve larvae in the Western English Channel with traditional and molecular techniques (S9-6959)

10:00 ***Coffee/Tea Break***

10:30 **Rhiannon L. Rognstad, Davis S. Wethey and Thomas J. Hilbish**
Intertidal population connectivity: The role of larval supply (S9-7257)

10:50 **Jennifer L. Fisher, William T. Peterson and Steven G. Morgan**
Nearshore larval retention among years and between regions of varying upwelling intensity (S9-7006)

11:10 **Claudio DiBacco, Heidi Fuchs, Jesús Pineda and Karl Helfrich**
Assessing swimming behavior and velocities of barnacle larvae in a downwelling flume (S9-7118)

11:30 **Diego A. Narváez, John M. Klinck, Eric Powell, Eileen E. Hofmann, John Wilkin and Dale B. Haidvogel**
Interannual and intraseasonal variability in dispersion of oyster larvae: A numerical study coupling an Individual-Based model to a hydrodynamic model. (S9-7269)

11:50 **Chad S. Gilbert, Wendy C. Gentleman, Catherine L. Johnson and Claudio DiBacco**
Modelling the influence of adult distribution, size-dependent fecundity and larval mortality on the dispersal of sea scallop (*Placopecten magellanicus*) larvae (S9-7292)

12:10 **Luis Felipe Skinner**
Daily larval availability and settlement of *Tetraclita stalactifera* (Cirripedia) at Cabo Frio, Brazil: Effect of tidal and upwelling transport (S9-7314)

12:30 Session ends

Posters

S9-6990 **Ali M. AlAidaroos**
Studies on the species diversity of selective brachyuran larvae from the Red sea along Jeddah coastline

S9-7016* **Elaine Fileman, Claudia Halsband-Lenk, Rachel Harmer and Pennie Lindeque**
(*Presenter: Co-Authors on behalf of Elaine Fileman*)
What's on the menu? Feeding rates and selectivity of meroplankton (decapod) larvae in the Western English Channel

S9-7061 **Lohengrin D. Fernandes, Jurema T. Quintanilha, Eliane Gonzalez-Rodriguez and Ricardo Coutinho**
Trend and seasonality in larval supply: A 15-year time series analysis of meroplankton in a coastal upwelling area in Southwestern Atlantic Ocean

S9-7104 **Andréa G. Koettker and Rubens M. Lopes**
Meroplankton assessment on the Abrolhos Bank, Brazil: Observations on major larval groups

S9-7159 **Cátia Bartilotti, Margarida Castro, A. Miguel P. Santos, Henrique Queiroga and Antonina dos Santos**
Distribution of decapod larvae off the Northwestern Iberia: Ontogenetic vertical migrations in the Portuguese upwelling ecosystem

S9-7239 **Juan Bueno, Ángel López-Urrutia and Antonina dos Santos**
Phenology and dispersion patterns of decapod larvae in the Cantabrian Sea during 2006

S9-7267 **Ernesto Díaz-Cabrera, Eduardo Hernández-Miranda, Cristián E. Hernández and Renato A. Quiñones**
Mesoscale beta diversity and spatial nestedness of crustacean larvae in the coastal zone off central-southern Chile

List of Posters from General Poster Session (GP)

GP-6879 **C.O. Olaniyi**
Comparative studies on the performance and survival rate of fish larvae fed *Artemia* vs. cultured freshwater zooplankton

GP-6984* **Tania FitzGeorge-Balfour, Andrew G. Hirst, Cathy H. Lucas and Jamie Craggs**
(*Presenter: Andrew G. Hirst on behalf of Tania FitzGeorge-Balfour*)
Digesting the errors associated with gut-content analysis in gelatinous zooplankton: An intercomparison of digestion time methods and recommendations

GP-7084* **Rodrigo J. Gonçalves, Mariela L. Spinelli, Rodrigo D. Hernández Moresino, Virginia E. Villafañe, Fabiana L. Capitanio and E. Walter Helbling**
(*Presenter: Mariela L. Spinelli on behalf of Rodrigo J. Gonçalves*)
UVR effects on nauplii from South Atlantic coastal waters (Patagonia, Argentina): Does food with high concentrations of UV-absorbing compounds make a difference?

GP-7107 **Peter H. Wiebe, Molly D. Allison, Robert C. Groman and Cynthia L. Chandler**
Data management in support of zooplankton research

GP-7144 **Shivanagouda N. Sanagoudra and M. Venkateshwarlu**
Zooplankton diversity in freshwater lakes with relation to trophic status, Shimoga district, Karnataka, South India

GP-7146 **Peter H. Wiebe, Gareth L. Lawson, Andone C. Lavery, Nancy J. Copley, Erich Horgan and Albert Bradley**
Enhanced capture of krill using an LED based strobe light on a 1-m2 MOCNESS

GP-7157 **Matilda Haraldsson, Cornelia Jaspers, Josefin Titelman, Dag L. Aksnes and Peter Tiselius**
A place for *Mnemiopsis*: Spatio-temporal habitat characterization in Scandinavian waters

GP-7184* **Astrid Cornils, Leocadio Blanco-Bercial, Sigrid B. Schnack-Schiel and Ann Bucklin**
(*Presenter: Ann Bucklin on behalf of Astrid Cornils*)
Molecular and morphological phylogeny of Paracalanidae, Giesbrecht 1892 (Copepoda: Calanoida)

GP-7200 **Lai Peng Foong, Tomohiko Kikuchi and Tatsuki Toda**
Chromosome studies on the marine harpacticoid copepod *Euterpina acutifrons* (Dana, 1848)

GP-7205 **Leslie E. Nasmith, Claudio DiBacco, Donald B. Humphrey and Colin D. Levings**
Assessing the relative risk of inter- *vs.* intra- coastal ballast water transport of non-indigenous zooplankton

GP-7214* **Erik Muxagata and John A. Williams**
(*Presenter: Felipe Gusmão on behalf of Erik Muxagata*)
Barnacle larvae production on Southampton Water, England

GP-7231 **Todd D. O'Brien**
COPEPOD: A global plankton database with data and DATA

GP-7243* **M. Loreto Torreblanca, Carmen E. Morales, Marco Correa-Ramírez, Samuel E. Hormazábal and Pamela Hidalgo**
(*Presenter: Co-Author on behalf of M. Loreto Torreblanca*)
Copepod distribution in a pair of mesoscale eddies off Concepción, central-southern Chile

GP-7260 **Hege Vestheim, Paolo Simonelli, Jorun Egge, Tom Andersen, Frede Thingstad and Ketil Hylland**
Zooplankton community response to multiple anthropogenic stressors

GP-7262 **Josefin Titelman, Kazutaka Takahashi, Kajsa Tönnesson, Danilo L. Calliari, Lene Friis Möller and Peter Tiselius**
Predation and diel behavioral patterns in a Chaetognath

GP-7264 **Elvire Antajan, Morgane Travers-Trolet, Christophe Loots and Sandrine Vaz**
Winter distribution of *Mnemiopsis leidyi* (Agassiz, 1865) in the southern North Sea and first record in French waters

GP-7274 **Christian Briseño-Avena, Jules Jaffe, Mark D. Ohman and Paul L.D. Roberts**
Dormancy in *Calanus pacificus californicus*: Are copepods safe from predators while overwintering?

GP-7281* **Erik Muxagata, Waldemar J.A. Amaral and Carla N. Barbosa**
(*Presenter: Felipe Gusmão on behalf of Erik Muxagata*)
Secundary production of Acartia (Copepoda: Calanoida) in Patos Lagoon Estuary

GP-7291 **Mark C. Benfield**
Industry ADCPs reflect the responses of zooplankton and micronekton to the Deepwater Horizon oil spill in the Gulf of Mexico

GP-7294 **M. Sonia Barría de Cao, M. Celeste López Abbate, Rosa E. Pettigrosso, Karin Fulco and Mónica S. Hoffmeyer**
Microzooplankton dynamics in the Bahía Blanca Estuary, Argentina

GP-7301* **M. Loreto Torreblanca and Carmen E. Morales**
(*Presenter: Co-Author on behalf of M. Loreto Torreblanca*)
Distribution of the copepods *Calanus chilensis* and *Calanus australis* in the coastal band, coastal transition zone, and oceanic waters off central-southern Chile

GP-7313 **Sergio Núñez, Carolina Parada and Ramiro Riquelme-Bugueño**
Advances in biophysical modeling of *Euphausia mucronata* in the Southeast Pacific

GP-7325 **Kazutaka Takahashi, Tadafumi Ichikawa, Hiroaki Saito, Shigeho Kakehi, Yasunori Sugimoto, Kiyotaka Hidaka and Koji Hamasaki**
Sapphirinid copepods as predators of doliolids: Their contribution to doliolids mortality and sinking flux

GP-7357 **Gary Borstad, Leslie Brown, Mei Sato, David Lemon, Randy Kerr and Peter Willis**
Analysis of zooplankton time series from an upward looking sonar: The data-cube concept

GP-7549 **Tao Zuo, Rong Peng and Qun Lin**
Spring size spectra and production of net zooplankton in Laizhou Bay, Bohai Sea

Abstracts
Oral Presentations

Opening Plenary Session

March 14, 8:50 (Plenary-7339)

Climate change and planktonic ecosystems: Detection, understanding and projection

Grégory **Beaugrand**

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Climate change is unambiguous and its effects are clearly detected in all functional units of the Earth System. In the marine biosphere, changes are seen from phytoplankton to zooplankton to fish and are modifying the dominance of species and the structure, the diversity and the functioning of marine ecosystems. Climate change has implicated pronounced biogeographical and phenological shifts for many species and sometimes critical transitions. Mechanisms are complex because they are often nonlinear, exhibiting tipping points and varying in space and time. Sensitivity of organisms to temperature changes is high, implicating that a small temperature modification can have sustained ecosystem effects. This talk uses a global scale approach to review how climate change might modify biological systems from the species to the ecosystem level. It highlights major progresses that have been accomplished in our field and major conceptual issues we need to address in the decade to come. A new (challenging and perhaps provocating) framework is presented to explain how biogeographical, phenological and abrupt ecosystem shift might be linked. The focus is made on detection (monitoring and statistico-mathematical tools), potential mechanisms at work and projection (new modelling tools). The talk also stresses that unanticipated changes, called surprises in climatic research, might make projections of future biological trajectories more difficult to achieve in a warmer world. Some recommendations on future research and on scientific programmes are proposed. To face Global Change a coordinated and worldwide approach that includes global monitoring, new mathematical tools for detection, and new types of modelling is needed.

March 14, 9:30 (Plenary-7232)

Zooplankton role in biogeochemical cycles: Progress and prospects for the future

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Through their feeding and metabolism, zooplankton plays an integral role in the cycling of carbon and nutrients in the sea. This presentation will address some of the recent progress in our understanding of how zooplankton affects biogeochemical cycling, and what are important gaps in our knowledge that still remain. Zooplankton export processes, such as fecal pellet production and diel vertical migration, can have significant effects on the magnitude of the biological pump, which regulates in part atmospheric CO_2 and hence can impact climate. We are at the point now that we can begin to compare the role of zooplankton in the biological pump across diverse ecosystems. In addition, zooplankton time series reflecting human and climate-influenced changes in zooplankton biomass and community structure can be used to determine associated changes in biogeochemical cycling, and to predict future changes. Zooplankton community structure affects the quality and quantity of dissolved inorganic and organic matter they produce, which in turn can affect microbial growth, community structure, and metabolism. The role of some major groups (*e.g.*, gelatinous zooplankton) and process rates in major habitats (the meso- and bathypelagic zones) are still insufficiently known, and are needed to incorporate the role of zooplankton into predictive biogeochemical models. Development of new technologies, more sensitive measurement techniques, novel biogeochemical tracers, and our input as a community into design of ocean observatories will be the key to continued progress.

March 14, 10:30 (Plenary-7112)

The giant jellyfish (*Nemopilema nomurai*) bloom in East Asian seas: Causes, consequences and countermeasures

Shin-ichi **Uye**

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The giant jellyfish, *Nemopilema nomurai*, whose maximum bell diameter, body weight and fecundity attain 2 m, 200 kg and 1 billion eggs, respectively, is released as ephyra in April-May from benthic polyps occurring in a large bay system flanked by the Korean Peninsula and the Chinese mainland (*i.e.* the Bohai, Yellow, and East China Seas). Young medusae grow within the offshore-spreading Chang Jiang low salinity water mass, and are then transported northeastward to the Japan Sea by the Tsushima Current. Massive blooms of this species used to be rare, occurring about every 40 years, but have recently occurred almost annually since 2002. In July 2009, some 22 billion young medusae occurred in Chinese and Korean nursery grounds and ca. 90% of them were later found in the Japan Sea, adversely affecting fisheries. Recent frequent blooms may indicate that environmental conditions conducive to such outbreaks (*e.g.* over-fishing, global warming, eutrophication and marine construction) have prevailed for some time and may even become exacerbated due to on-going Chinese economic development. Therefore, it is imperative to take urgent countermeasures to mitigate the damage from recurring jellyfish plagues. Forecasts of year-to-year bloom intensity are undertaken based on visual surveys of young medusae en route to Japanese waters using international ferries, enabling fishermen to prepare well in advance for possible jellyfish attacks. Japanese set-net fishermen are modifying their nets by installing a bypass net and a partition net, which are effective in separating entrapped medusae from fish which otherwise would cause considerable damage.

March 14, 11:10 (Plenary-7277)

Modes of climate and food web variability in high latitude oceans

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There are a number of similarities and differences in zooplankton communities and processes between the Arctic Ocean and the Southern Ocean, owing to inherent environmental properties and food web interactions. Both systems are subject to large-scale climate forcing, strong seasonal cycles in irradiance and primary production, and are characterized by cold seawater temperatures and sea ice cover. In addition, both the Arctic and parts of the Southern Ocean currently are among the most rapidly warming regions on Earth. Copepods are common to both regions; however, euphausiids often dominate in the Southern Ocean and appendicularian blooms frequently occur in the Arctic Ocean and its marginal seas, influencing food web dynamics and biogeochemical cycles. In general, the impact of mesozooplankton grazers on primary production depends on the abundance of herbivores and phytoplankton, as individual grazing rates are relatively high. The impact of microzooplankton appears to be variable depending on the location and season. The role of large-scale climate forcing and changes in regional environmental processes will be discussed with respect to observed and predicted impacts on high latitude zooplankton and food web interactions.

March 14, 11:50 (Plenary-7115)

Composition and succession of zooplankton communities: A global comparison

Torkel Gissel **Nielsen**

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Zooplankton plays a central role in the pelagic food web through grazing and providing food for higher trophic levels. Furthermore, they contribute to the recycling of nutrients and the production of fast-sinking fecal pellets. Most investigations of marine pelagic food webs consider either the classical food web such as mesozooplankton, or the microbial components of the food web. Here, I present our investigations that integrate both, and show how the succession of these parts of the pelagic food web vary with latitude *i.e.* the seasonality of forcing factors such as ice, light, temperature, wind and nutrient availability.

In most pelagic ecosystems from the arctic to the equator, mesozooplankton production are food limited except where and when they encounter blooms of large phytoplankton. Outside the main blooming season, and in areas dominated by small species of phytoplankton, copepods feed on protozooplankton that in turn feed on small phytoplankton too small to be fed upon by copepods.

Protozooplankton biomass on the other hand is regulated by predation from mesozooplankton. Throughout the year, the impact of copepods predation varies. Outside the main blooms, copepods regulate protozooplankton biomass by directly feeding on them. However, protozooplankton biomass can recover during so-called “regulation vacuums” *e.g.* during phytoplankton blooms when copepods become food saturated and the predation on the protozooplankton relaxes, or when copepods are not present in the euphotic zone *e.g.* when they migrate to deep waters to hibernate.

S3 Oral Presentations

March 14, 14:05 (S3-7057), Invited

Life cycles and life history adaptations of pelagic tunicates

Don **Deibel** and Ben Lowen

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Pelagic tunicates are ecologically and evolutionarily significant. They consist of two classes within the subphylum Tunicata, the Appendicularia (or Larvacea), and the Thaliacea (*i.e.* salps, doliolids and pyrosomids). They are holoplanktonic and pure suspension feeders, and with only a few exceptions are hermaphroditic. Because the tunicates are the most closely related invertebrates to the vertebrate chordates, they have long been of interest in the study of chordate origins and evolution. Phylogenetic data indicates that the chordates are monophyletic, but with tunicates as the sister group rather than cephalochordates. The Thaliacea are all colonial and a sister group to the colonial, benthic Phlebobranch and Aplousobranch ascidians, while the solitary Appendicularia are a sister group of the solitary, benthic Stolidobranch ascidians. Thus, while the appendicularians have a simple life cycle and solitary life history stages, the thaliaceans demonstrate increasing life cycle complexity, from colonial salps with two life history stages to colonial doliolids with five life history stages. The complex life histories of salps and doliolids include alternation of sexually and asexually reproducing generations, which is also typical of ferns and higher plants. Case studies will be summarized, demonstrating life history adaptations of pelagic tunicates to environmental variability. We will focus on rapid development and late oocyte selection in appendicularians (clutch size manipulator) and factors leading to high rates of asexual reproduction in thaliaceans. These case studies draw attention to adaptations of pelagic tunicates to phytoplankton blooms, demonstrating that they are not solely creatures of oligotrophic ocean gyres.

March 14, 14:30 (S3-6973)

Explaining the mass occurrence of a deepwater scyphomedusa in Norwegian fjords

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Mass occurrence of the coronate scyphomedusa *Periphylla periphylla* in several Norwegian fjords contrasts the low abundance in deep waters in the open ocean. The sheltered fjords provide unique possibilities for studying the life strategy of this deepwater species and the factors involved in its population success here. Studies over many years have revealed a life cycle with a slow growth, maturity at 3-4 years of age, and a life span of 10-15 years. Mature animals migrate to the surface during darkness, probably for mating, and the ripe eggs released sink to midwater depth where they develop from immobile embryos to functional small medusae over the first half year. Simple models show the benefit of *e.g.* vertical migration for mating success, of repeated spawning over one annual event, and egg buoyancy for life in midwater depth. Surface aggregation may increase the probability of mate encounter strongly. If turbulent mixing is the main factor to mix released eggs and sperms, probability of encounter increases hundred to thousand-fold in a surface aggregated population. Chemical signaling, dependent mainly on molecular diffusion, may benefit even more. The buoyancy of free-floating eggs and embryos keep them away from abundant predators in shallow depths and on the bottom, but also provides a physical shelter for being washed out by *e.g.* tidal currents. It is suggested that the life strategy of *P. periphylla* is shaped from its original habitat in the open ocean, but that this strategy is especially well suited for life in some Norwegian fjords.

March 14, 14:50 (S3-7042)

The physical characteristics of the Baltic Sea might act as a bottleneck for the *Mnemiopsis leidyi* population expansion in this newly invaded area

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The recent invasion of the comb jellyfish *Mnemiopsis leidyi* into European waters has given rise to major public concern due to its fast population build up and high grazing impact. One of the key features making *Mnemiopsis* such a successful invasive species is its high fecundity with thousands of eggs produced individual^{-1} day^{-1} combined with fast growth rates. To evaluate the potential impact of its invasion into the Baltic Sea, it is important to understand the reproductive output under different environmental regimes. Here we present results of *in situ* egg production rates of *Mnemiopsis* in different regions of the Baltic Sea. We show that *Mnemiopsis* is actively reproducing during summer and autumn in the Baltic Sea. Egg production rates scale with animal size and production rates are significantly ($p<0.001$) higher in the Kattegat compared to the southern and central Baltic Sea, irrespective of lower food availability in the Kattegat. Our results imply that salinity acts as a potential bottle neck for population expansions in this newly invaded area and that the higher saline Kattegat might act as a source area for the *Mnemiopsis* population in the Baltic Sea.

March 14, 15:10 (S3-7005)

Spatial connectivity and cycles of *Pelagia noctiluca* (Semaeostomeae, Scyphozoa)

Alenka **Malej**, Vlado Malačič, Andreja Ramšak, Tjaša Kogovšek and Katja Stopar

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Many gelatinous zooplankton taxa have life histories with characteristic massive outbreaks that can cause harmful consequences. Medusae which occur in large aggregations predominantly belong to Scyphozoa that have a metagenic life cycle; a notable exception is holoplanktonic *Pelagia noctiluca*. Low genetic differentiation of this jellyfish over a large spatial scale (Mediterranean Sea and Eastern Atlantic) and a lack of isolation by distance indicate that *Pelagia* populations are demographically open and have considerable dispersal capabilities. We used 3D Lagrangian trajectories to infer dominant distance modes of dispersal for *Pelagia* in the Mediterranean sub-region (Adriatic Sea). The length of trajectories had a bimodal distribution with high frequencies at either 100-300km or at about 1.500km; almost half the computed distances were >500km, not much shorter than the length of the Adriatic Sea (~800km). The *Pelagia* holoplanktonic life history traits with an extended reproduction period, external fertilization and opportunistic feeding facilitate the formation of connected sets of populations with synchronous dynamics over large distances. Wavelet analysis of *Pelagia* long-term (~200 years) and decadal (~30 years) time series confirmed similar periodicities (8–12 years, 2.5 years, 8-14 months) in different parts of the Mediterranean Sea (western Mediterranean, Adriatic Sea, Aegean Sea).

March 14, 15:30 (S3-7002)

Relative abundance of life history stages of the ubiquitous salp *Thalia democratica* in different water types

Natasha **Henschke**[1,2], Jason D. Everett[1,2], Mark E. Baird[2,3], Matthew D. Taylor[1,2] and Iain M. Suthers[1,2]

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Swarms of the salp, *Thalia democratica*, occur periodically off southeast Australia, peaking during the austral spring bloom of phytoplankton. This study determined the abundance and size distribution of *T. democratica* in three water types of the western Tasman Sea from vertical net hauls along four cross-shelf transects between 32 to 34°S. Temperature-salinity signatures grouped stations into three distinct water types: inner shelf water, East Australian Current (EAC), and upwelled water. Although common across all stations, *T. democratica* was significantly more abundant within inner shelf waters compared to upwelled water. Analysis of population structure identified higher proportions of the asexually reproducing solitary stages and sexually reproducing aggregates in the inner shelf water type. The maximum abundance of *T. democratica* was similar to the highest globally recorded abundance, and tenfold greater than maximum abundances sampled using a similar net in these waters during 1938-42. Possible reasons include the strengthening of the East Australian Current, which has warmed the waters of SE Australia by over 2.3°C in the past 80 years.

March 14, 16:20 (S3-6997)

Neocalanus ocean vs. *Calanus* ocean: Implication as characteristics of planktonic ecosystem in the North Pacific

Shinji **Shimode**[1], Mitsuhiro Toratani[2] and Atsushi Tsuda[1]

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It has been well known that zooplankton community in the subarctic Pacific is dominated by three large *Neocalanus* spp., implying that the North Pacific is a "*Neocalanus* ocean", which is comparable to the North Atlantic as "*Calanus* Ocean". However, four endemic *Calanus* spp. are also known form the North Pacific. To clarify the distribution of *Calanus* and *Neocalanus* spp., we collected zooplankton samples in the NW Pacific (ca. 50–15ºN, 165–125ºE). *Neocalanus* spp., including two tropical congeners, occupied 62.4% of the total abundances of the two genera in the survey area. On the other hand, high frequencies of *Calanus* spp. were found at stations located from 45 to 30ºN, most of which agreed with a relatively high Chl-*a* area in the Kuroshio–Oyashio transition region. Our result indicates that *Neocalanus* spp. dominates environments with low food availability, such as subarctic and subtropical gyres in the North Pacific, whereas *Calanus* spp. prefer relatively high productive regions. The difference appeared to be caused by differences in the reproductive strategies between the tow groups. These *Calanus* spp. are "income spawners" that produce eggs in the surface using nutrition from concurrent grazing. In contrast, *Neocalanus* spp., at least three subarctic species, are "capital spawners" that produce eggs in the deep layers using energy accumulated during the previous year, which is considered as an adaptation to the low-food environment. Our result would be applicable to the congeners distributed in the other ocean regions.

March 14, 16:40 (S3-7068)

Understanding copepod life-history and diversity using a next-generation zooplankton model

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Global climate models now provide realistic depictions of the impacts of climate variability and anthropogenic climate change on physical conditions in the oceans. Understanding the complex interactions between the ocean's dynamic physical environment and the distribution, abundance and productivity of the pelagic species is a precondition for using climate models to predict the impact of climate change on marine ecosystems. From this perspective, copepods represent a critical link in pelagic ecosystems that connect environmental variability and changes in primary production with higher trophic levels.

Predicting ecological changes under climate change requires mechanistic descriptions of the impact of the environment on physiology, life history, and population dynamics. We have developed a model of copepod abundance as a function of size (mass) and developmental stage. The goal was to develop a model framework that can be applied to a wide range of calanoid copepods, and that will mechanistically model their abundance and phenology. This model incorporates trade-offs between development, growth, and size-structured mortality and includes realistic dormancy strategies and vertical migrations. We discuss how this model can provide insights into species adaptation to particular environments, using the well-known boreal/arctic Calanus complex as the focus (*C. finmarchicus*, *C. glacialis* and *C. hyperboreus*). This step prepares the implementation of a series of selection experiments that will test hypotheses about the processes that control diversity in communities of copepods, with an eye toward interpreting results from the North-West Atlantic.

March 14, 17:00 (S3-6964)

Does predation control adult sex ratios and longevities in marine pelagic copepods?

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3 Marine Biological Association of the United Kingdom, Plymouth, Devon, UK
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We assess the causes of adult sex ratio skew in marine pelagic copepods by examining changes in these ratios between the juveniles and adults, sexual differences in juvenile stage durations, and mortality rates of adults in the field and laboratory (when free from predators). In the field, late copepodite stages (CIV and CV) commonly have sex ratios that are either not significantly different from equity (1:1), or slightly male biased. By contrast, in adults, these ratios are commonly significantly biased toward female dominance. Sex ratio skews are therefore primarily attributable to processes in adults. Members of the non-Diaptomoidea have especially skewed adult ratios; in the members Oithonidae and Clausocalanidae this is not generated from differences between male and female adult physiological longevity (*i.e.*, laboratory longevity, when predator free). In the genera *Acartia*, *Oithona*, and *Pseudocalanus*, we estimate predation mortality contributed ≥69% of the field mortality rate in adult males, whereas in *Acartia*, *Oithona*, and *Calanus* adult females, this is ≥36%. We conclude that (1) adult sex ratio skew in pelagic copepods is primarily due to differential mortality of the sexes in adults, (2) mortality rates of adult *Acartia*, *Pseudocalanus*, and *Oithona* are dominated by predation mortality rather than physiological longevity (except under extreme food limitation), and (3) in *Pseudocalanus* and *Oithona*, elevated mortality rates in adult males to females is predominantly due to higher predation on males. We now need to develop a more comprehensive understanding of the importance of feeding preferences in predators, and role of Environmental Sex Determination (ESD).

March 14, 17:20 (S3-7125)

Life history of *Euphausia pacifica* in the northern California current: What can be learned by contrasting field and laboratory studies

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The life history of *Euphausia pacifica* is closely tied to the seasonal cycle in the dynamic upwelling region off central Oregon, U.S.A. With 14 years of field data available off of Newport, Oregon, we can confidently use our time series for traditional estimations of *E. pacifica* growth rates, survivorship, time to maturity, length of spawning season and spawning frequency. We contrast these field data with 10 years of laboratory studies on *E. pacifica* larval development, growth rates, brood sizes, long-term fecundity and ages of individuals. Laboratory studies reveal the large scale of individual variability which is often obscured by the use of population data for estimation of life-history parameters and vital rates. For instance, cohort data suggests a mean adult growth rate of 0.05mm per day. The mean adult growth rate from our instantaneous growth rate experiments is 0.02mm per day which is a good confirmation of the cohort data, but reflects the far greater frequency of negative growth measured at the individual level. Our predicted brood size from field densities of females and eggs is on the order of 87 eggs per brood; however laboratory experiments show that the mean brood size for *E. pacifica* in this region is approximately 150 eggs with a range from 3-800 eggs per brood. Knowledge of the full range of rates displayed by this animal allows for a better understanding of their interactions with the physical environment and potential responses to changing ocean conditions.

March 14, 17:40 (S3-7100)

Behavior and life-history strategies of Northern krill (*Meganyctiphanes norvegica*) and its impact on population dynamics and spatial distribution: Results from a spatial explicit individual-based model with external forcing

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Meganyctiphanes norvegica is the dominant species of krill in the North Atlantic. It lives for about 2-3 years and grows to a length of about 45mm. The species is omnivorous and have been reported to forage on phytoplankton, zooplankton and to some extent detritus.

We present an individual based model of *M. norvegica* in the Norwegian Sea in a 3D spatial setting influenced by sea temperature, light conditions and not at least ocean currents. Monthly fields of phytoplankton and zooplankton are also included and together used to calculate vital rates. The whole life cycle of *M. norvegica* is modeled with a total of 12 stages from egg to adult.

Northern krill's main competitor for phytoplankton (*Calanus* sp.) is also the most common zooplankton prey found in stomach samples. This places *M. norvegica* in a somewhat special and interesting role in the marine food web and the model is presently being implemented in the NORWECOM end-to-end ecosystem model for the Norwegian Sea.

Five life-history traits related to vertical migration behavior and spawning behavior are optimized to maximize individual fitness during simulations. Normally krill is considered plankton, but adult *M. norvegica* have been shown to migrate vertically with almost 1 body length per second. We investigate how various vertical and horizontal movement strategies can impact model distribution and help explain observed distribution patterns. Distribution and population dynamics is compared to year-long field surveys.

S6 Oral Presentations

March 14, 14:05 (S6-7484), Invited

Adaptations to seasonality and the annual routine perspective for zooplankton

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The biosphere displays an impressive variability of environments, some towards endpoints on gradients in abiotic (and biotic) conditions and therefore termed extreme. Polar habitats are often viewed as extreme, not by the organisms evolved to live there but by us who investigate their living. Low temperatures, sea ice, and strong seasonality in light and primary production are among the characteristics of high latitude ecosystems. Seasonality in solar irradiance is the key driver. The behavior and life history strategies of polar zooplankton, and consequently their population dynamics, must be studied with an explicit focus on seasonality. A key challenge is to understand how processes through the annual cycle are linked. For instance, how does a change in a spring phenomena, such as the timing or amount of egg production, influence an autumn process such as energy storage or seasonal migration? Individual lifetime fitness consequences and trade-offs couple these temporally separated events and the recently established framework of annual routines captures our methodological challenge. Annual routines can be viewed as the scheduling of life history events or activities over a seasonal cycle in an evolutionary perspective including physiological constraints and individual body conditions or states. Here I present an introduction to annual routine models and suggest how this approach can guide current zooplankton studies, including our investigations of how zooplankton respond to environmental variability and change.

March 14, 14:30 (S6-6880)

Microzooplankton grazing in Arctic waters

Albert **Calbet**[1], Enric Saiz[1], Karen Riisgaard[2], Rodrigo Almeda[1], Ignacio Movilla[1], Miquel Alcaraz[1], Sara Zamora[1] and Torkel Gissel Nielsen[2]

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We studied the structure and dynamics of the microbial community of Arctic (high Arctic, North Svalbard Islands; July 2007) and subarctic waters (Fyllas bank and Godthåbfjord, Greenland; June 2010) using a microzooplankton grazing dilution approach. Overall, the experiments in both zones presented contrasted results. In high Arctic waters the phytoplankton community was dominated by a senescent bloom of *Phaeocystis pouchetii*, which strongly influenced the functioning of the microbial food web. Despite the considerable biomass of microzooplankton (mostly large ciliates and dinoflagellates), their grazing impact on phytoplankton was low, and significant only in 6 out of 16 experiments for total chlorophyll *a*, which resulted in 8% of the standing stock consumed on average. In Greenland waters we found a different situation, with a clear gradient in microzooplankton grazing impact on primary production along the fjord, variable (not significant most of times) in the Fyllas Bank and outer part of the fjord, and quite intensive (up to >100% PP consumed daily) inside the fjord. We try to explain these differences based on the characteristics of the community found in each area, and provide a general view of the role of microzooplankton in the Arctic.

March 14, 14:50 (S6-7220)

The energy budget of egg production in Calanus glacialis during spring and summer in the Beaufort-Chukchi Seas

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A comprehensive data set of *Calanus glacialis* female body size, oil sac volume, and ingestion and egg production rates measured during spring and summer of 2002 and 2004 as part of the Shelf Basin Interactions program is used to describe the energy budget of egg production of this key species in the Beaufort-Chukchi Seas. We built a carbon-based energy budget of daily assimilation and egg production (EPR) based on measured carbon weights of females and eggs, and assimilation efficiency and respiration rates estimated from the literature. Overall, we found that ingestion/assimilation was roughly equivalent to EPR. However, there were marked interannual and seasonal variations. While carbon assimilation exceeded carbon produced as eggs by a factor of 1.7 and 5.5 under generally high algal food concentrations in spring and summer of 2004, feeding activity only accounted for 60% and 50% of the carbon produced as eggs in spring and summer 2002 in much lower chlorophyll *a* biomass. The importance of grazing on microzooplankton showed an opposite pattern representing 40% and 10% of the carbon ingested in 2002 and 2004 respectively. The deficit in carbon ingestion relative to EPR observed primarily in 2002 suggests that body reserves and/or other food sources such as ice algae and early development stages of copepods (cannibalism, predation) were utilized by females to fuel EPR. These results will be analyzed relative to the life cycle strategy of *C. glacialis* and ice cover and general oceanographic conditions observed in the Beaufort-Chukchi Seas in 2002 and 2004.

March 14, 15:10 (S6-6883)

Plankton community structure and role of *Oithona similis* on the western coast of Greenland

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The genus of small marine copepods *Oithona* (O. Cyclopoida) has been acknowledged as an important component of the pelagic food webs, albeit its function in the ecosystem is still not well known. Within this genus *O. similis* is probably the most cosmopolitan species, being distributed from polar to tropical waters. In this study we aimed to assess its trophic role in Arctic waters, where it could play a key role during those periods of the year when the large calanoids are not present. Two different locations were studied in the west Greenland coast: waters offshore Godthåbsfjord (Nuuk) during the winter time (pre-bloom conditions), and Disko Bay during the spring time (bloom conditions). We carried out grazing experiments to determine the feeding rates of *Oithona* on phytoplankton and microheterotrophs, and also studied the vertical distribution of its potential prey. In these contrasting situations we found that ciliates were a major component of the diet of *Oithona similis,* being consumed preferentially to other components of the microplankton community.

March 14, 15:30 (S6-6948)

Population dynamics and life strategy of the copepod *Metridia longa* in a Greenlandic fjord, 2010

Sanne **Kjellerup**, Rasmus Swalethorp, Karen Riisgaard and Torkel Gissel Nielsen

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Knowledge about the structure of Arctic pelagic food webs is essential to assess the impact of the ongoing climate change on the marine ecosystem. Previous studies primarily focused on the large copepod genus *Calanus* as grazers, as this genus dominates the mesozooplankton community in Arctic waters. However, if night sampling is included the omnivorous copepod *Metridia* spp. will be dominant in some areas. The biology of *Metridia* is little known and appears to deviate in many ways from that observed for *Calanus*. In contrast to *Calanus*, *Metridia* does not hibernate but stays active year long benefiting from being an omnivore. This ability could also prove an advantage in coping with climate induced changes to the base of the food web. Abundance, depth distribution and egg and pellet production of *Calanus finmarchicus*, *C. glacialis* and *Metridia longa* were monitored weekly in 2010 in a Greenland fjord. *M. longa* performed diel vertical migrations of more than 200 meters and was clearly the dominant species in the study area, which is believed to be a principal spawning ground for the Atlantic cod. *M. longa* contributed to >90% of the mesozooplankton biomass particularly in midnight samples. Carbon and lipid content of *M. longa* was also monitored weekly to evaluate copepod condition as well as their quality as food items for higher trophic levels. The findings will be discussed in relation to water column properties and potential food items, to advance the understanding of trophic interactions and energy transfer within the vulnerable Arctic food-webs.

March 14, 16:20 (S6-7135)

Is Arctic zooplankton sleeping in the winter?

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According to traditional perception, Arctic zooplankton spends the winter with little activity, using up energy stored during the previous productive season. Our studies in the Barents, Kara and White seas under typical winter hydrographic conditions in March and April 2001 and 2003 demonstrated, however, that only predominantly herbivorous zooplankton species were in an inactive state during mid and late winter. The more opportunistic feeders, such as small copepods *Pseudocalanus* spp., *Drepanopus bungei*, *Oithona similis*, which made up a large fraction of the winter zooplankton abundance and biomass in the studied shelf regions were actively reproducing (*e.g.*, *P. major, D. bungei* and *O. similis*) or have just commenced reproduction (*e.g.*, *P. minutus*) despite extremely low phytoplankton abundance. Predators such as chaetognaths *Parasagitta elegans* and ctenophores have also started to reproduce at the end of winter. A wide prey size spectrum from the meroplanktic larvae of benthic animals (gastropoda and bivalvia, nudibranchians, bryozoans) produced from lipid reserves, the offspring of zooplankton omnivores, and the overwintering stages of herbivores provided favorable conditions for adults and young larvae of these predators. Although there are some regional differences in faunistic composition of zooplankton between the three studied seas, the zooplankton communities in all of them were to a large extent "awake" at the end of winter and capable of exploiting upcoming phytoplankton blooms. Moreover, these communities seem to be well prepared in the future to exploit earlier spring phytoplankton blooms in response to earlier ice melt.

March 14, 16:40 (S6-6993)

A phytoplankton bloom controlled by zooplankton grazing during the LOHAFEX iron-fertilisation experiment in the S-W Antarctic Circumpolar Current

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The iron fertilisation experiment LOHAFEX was conducted in the S-W Atlantic branch of the Antarctic Circumpolar Current (48°S; 16°W) where 10 tonnes of dissolved ferrous sulphate were spread over a patch (eddy) of 150 km^2. The chemical and biological changes stimulated by the iron fertilisation were followed for 39 days (January-March 2009). Zooplankton investigations within LOHAFEX were aimed at studying the structural and functional responses of primary and secondary consumers to food availability, and estimating their impact on the carbon flux during the evolution of the phytoplankton dynamics induced by the iron fertilization. Sampling devices included plankton nets (RMT, Multinets, WP2), oceanographic bottles, underwater video profiles (UVP) and neutrally-buoyant sediment traps. Our results showed that mesozooplankton was dominated by the copepods *Calanus simillimus* in biomass and *Oithona similis* in numbers, with highest abundances in the range of 7.8-84.1 x 10^3 ind. m^{-2} and 2.4-270.4 x10^3 ind. m^{-2}, respectively, in the upper 200 m of the water column. Macrozooplankton was dominated by the swarm-forming carnivorous amphipod *Themisto gaudichaudii* with abundances up to ~1 ind. m^{-3}. *Calanus simillimus* ingested between 5 and 25 µgC ind^{-1} d^{-1} (8-40% of body carbon per day). Thus, despite high growth rates, the biomass of non-diatom phytoplankton was controlled by grazing pressure of oceanic copepods. The zooplankton faecal material flux (<1–6.9 mgC m^{-2} d^{-1}) made a significant contribution (~40%) to total POC flux, where the low carbon sequestration below 450m depth suggests that a "copepod recycling system" was established.

March 14, 17:00 (S6-7193)

Diel vertical migration of the pelagic tunicate *Salpa thompsoni* in the Southern Ocean

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Diel vertical migration (DVM) is a well-known behavior observed in various zooplankton groups. We investigated the detailed pattern of vertical distribution of the pelagic tunicate *Salpa thompsoni* using both successive net samplings with a MOCNESS-1 system and visual image analysis using LAPIS (Large Area Plankton Imaging System) in waters off the Continental Shelf west of the Antarctic Peninsula. During the study period, most of the salp populations were distributed in the upper 500m and clear DVM of salps was observed within this depth range. At a station where higher chlorophyll waters contained swarms of krill juveniles near the surface, most of the salp population migrated down to 300-500 m during the day. By contrast, at a station where relatively low chlorophyll concentrations were observed, the salps seemed to migrate up to the surface at night but stopped migrating down during the day at the bottom of highest chlorophyll layer (70m). Lower gut pigments were found in salps at the low-chlorophyll station than in the high-chlorophyll station. Present results suggest that the salps may be able to change DVM behavior in relation to the food availabilities. The DVM of salps may enable them to avoid the extremely high food concentrations to prevent the clogging of their feeding nets and also enable them to stay longer at depth layers with suitable food concentrations, resulting in overall increases of food availability.

March 14, 17:20 (S6-6888)

Arctic zooplankton in a warming scenario: Metabolism, tipping points and stoichiometry of regenerated nutrients

Miquel **Alcaraz**[1], Rodrigo Almeda[1], Enric Saiz[1], Albert Calbet[1], Carlos M. Duarte[2], Susana Agustí[2], Rocio Santiago[2], Juancho Movilla[1], Alejandro Alonso[1], Jorge Felipe[1], Elena Arashkevich[3] and Ulrike Grote[4]

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The rise in ocean temperature and the reduction of sea ice extent in the Arctic can lead to important changes in the structural and functional properties of marine ecosystems, and zooplankton will definitely play a pivotal role in the expected changes. We studied the effects of temperature on the summer metabolic activity of Arctic zooplankton in the vicinity of the Svalbard islands during two cruises: ATOS-Arctic, July 2007, and ATP-1, June 2009. The objective was to determine the possible existence of temperature thresholds and tipping points in zooplankton metabolism and on the stoichiometry of their metabolic products.

During the ATOS-Arctic cruise, we assessed the relationships between zooplankton metabolic rates and the "in situ" temperature through a grid of stations representing a natural variation in temperature. Respiration was least dependent on temperature, followed by NH_4-N and PO_4-P excretion, resulting in an inverse relation between temperature and C:N, C:P and N:P metabolic quotients. During the ATP-1 cruise, copepods were exposed in the laboratory to a temperature gradient (0, 3, 6 and 10ºC), and the existence of temperature thresholds for respiration was determined. The 0–3ºC range exhibited the highest Q_{10}, suggesting that small temperature rises (about 3ºC) could induce significant changes in the stoichiometry of the inorganic N and P excreted by zooplankton, and eventually contribute to modifying the N:P ratio of regenerated dissolved nutrients available to phytoplankton. Above 6ºC, respiration rates significantly fell to values below their optima.

March 14, 17:40 (S6-6914)

Life history and biogeography of *Calanus* copepods in the Arctic Ocean: An individual-based modeling study

Rubao **Ji**[1], Carin J. Ashjian[1], Robert G. Campbell[2], Changsheng Chen[3], Guoping Gao[3], Cabell Davis[1], Geoffery Cowles[3] and Robert Beardsley[1]

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Calanus spp. copepods play a key role in the Arctic pelagic ecosystem. Among four congeneric species of *Calanus* found in the Arctic Ocean and its marginal seas, two are expatriates in the Arctic (*C. finmarchicus* and *C. marshallae*) and two are endemics (*C. glacialis* and *C. hyperboreus*). The biogeography of these species likely is controlled by the interactions of their life history traits and the physical environment. A mechanistic understanding of these interactions is critical to predicting their future responses to a warming environment. Using a 3-D spatially-explicit individual-based model, we show that *C. finmarchicus* is unable to penetrate into the Arctic Ocean under present conditions of temperature, food availability, and length of the growing season, mainly due to insufficient time to reach its diapausing stage and slow transport of the copepods into the Arctic Ocean during the growing season or even during the following winter, at the depths the copepods are believed to diapause. For the two endemic species, the model suggests that their capability of 1) diapausing at earlier copepodite stages and 2) utilizing ice-algae as a food source (thus prolonging the growth season length) contribute to the population sustainability in the Arctic Ocean. The inability of *C. hyperboreus* to attain diapause (C3) in the central basin, as demonstrated by the model, contradicts field observations and suggests that our current estimation of either the growth parameters or the growing season length (based on empirical assessment or literature) needs to be further evaluated.

S1 Oral Presentations

March 15, 8:35 (S1-7271), Invited

Zooplankton as sentinels of climate change

Mark D. **Ohman**

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In light of the myriad life history traits exhibited by different zooplankton taxa, it is hardly surprising that co-occurring taxa often show divergent responses to climate forcing. Yet many models – and measurement methods - continue to represent the zooplankton assemblage as a unitary entity, approximated by one or a small number of model compartments that are assumed to respond in a consistent manner to environmental perturbations. What is the correct level of resolution of the zooplankton that is both necessary and sufficient to detect climate signals? What levels of simplification can be adopted that still illuminate the key processes influencing zooplankton responses? Is the historical "target species" approach the correct way forward for the future? These questions will be addressed, drawing on zooplankton studies in the California Current System (CalCOFI region and the current CCE-LTER site). It will be shown that the appropriate resolution of the zooplankton assemblage requires understanding the role of ecological redundancy, the differential responses of endemics and exotics, and the potential amplification or reduction of climate signals by organisms with different life history traits.

March 15, 9:00 (S1-7064)

Potential effects of climate variability on oxygen minimum zone zooplankton communities

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Oxygen minimum zones (OMZs) may be expanding in their worldwide spatial and vertical extent, and this could have major effects on zooplankton community structure and ecosystem productivity in those regions. Using examples from different OMZs, especially the Arabian Sea and Eastern Tropical North Pacific, this presentation will highlight features of zooplankton distributions and community structure that would be most vulnerable to these changes. Within strong OMZs, the steep oxygen gradients (oxyclines) at the upper and lower boundaries create microhabitats of different oxygen concentration that are characterized by narrow layers of high zooplankton biomass, species zonation, and use in life history strategies. The depth and intensity of these layers may change, potentially impacting upper ocean and mesopelagic processes.

March 15, 9:20 (S1-6884)

Climate-related decadal dynamics in Baltic Sea zooplankton: Interactive and additive effects of bottom-up and top-down controls

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Climate variability can induce long-term changes in zooplankton populations directly through physiology as well as indirectly by changing the relative importance of bottom-up and top-down control. Changes in the strength of the controls can be interactive or additive with spatio-temporally varying species-specific responses.

Zooplankton in the semi-enclosed, brackish Baltic Sea live in an extreme environment with gradients and strong variability in salinity and temperature. Furthermore, food supply and predator abundance are strongly dependent on anthropogenic pressures such as eutrophication and overfishing. The Calanoid copepods *Acartia* ssp., *Pseudocalanus acuspes* and *Temora longicornis* are the major zooplankton species in the region and have different preferences for salinity and temperature. Additionally, they show a varying vulnerability to their main predators, the pelagic fish species sprat (*Sprattus sprattus*) and herring (*Clupea harengus*).

Here, we investigated interactive and additive effects of the various climate-induced long-term changes of main Baltic Sea zooplankton species. We compiled a unique time-series of seasonal monitoring data covering the last five decades, and combined data from different sources accounting for gear specific capture efficiencies. This allowed us to investigate intra-annual dynamics across three different regions of the Central Baltic Sea (Bornholm Basin, Gdansk Deep and Gotland Basin). By applying a suite of generalized additive mixed effect as well as threshold models, we identified driving factors and potential changes in bottom-up and top-down controls.

Our results clearly demonstrate how future climate change may alter species-specific and hence overall zooplankton community dynamics.

March 15, 9:40 (S1-7050)

Spatio-temporal variation of the plankton trophic interaction in the North Sea

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Traditionally, marine ecosystem structure was thought to be bottom-up controlled. In recent years, a number of studies highlighted the importance of top-down regulation. Evidence is accumulating that the type of trophic forcing varies temporally and spatially and an integrated view – considering the interplay of both types of control – is emerging. Correlations between time series spanning several decades of the abundances of adjacent trophic levels are conventionally used to assess the type of control: bottom-up if positive or top-down if this is negative. This approach implies averaging periods which might show time-varying trophic dynamics and therefore can hide part of this temporal variability. Using spatially-referenced plankton information extracted from the Continuous Plankton Recorder, this study addresses the potential dynamic character of trophic structure at the planktonic level in the North Sea by assessing its variation over both temporal and spatial scales.

March 15, 10:30 (S1-7170)

Limnetic zooplankton structure and distribution in Chilean lakes and reservoirs

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Knowledge of Chilean freshwater zooplankton has substantially accelerated since the development of the Man and Biosphere (MAB) - UNESCO Program, from 1975 onwards. The increase in the number of publications on zooplankton taxonomy and ecology during the last three decades, from two or three publications per decade, to one per year, allows a better understanding of the zooplankton structure in natural and man-made lakes. We present here an updated insight into species richness and latitudinal distribution of Copepoda (33 species, benthic taxa excluded) and Branquiopoda (41 species), the latter having an overall higher species richness and with a greater presence in reservoirs or more temperate and eutrophic systems. Maximum zooplankton species richness at approximately 40ºS also encompasses a higher percentage of copepods, as latitude and the proportion of oligotrophic water bodies increase. This latitudinal trend and the species richness pattern reported by Soto & Zúñiga (1991) are unaffected by the more recent surveys of the planktonic crustacean communities. These surveys and other ecological studies have provided a quantitative insight into freshwater systems components and the environmental relationships of the limnetic biota basic for climatic change research. We acknowledge the early influence to these local studies of the European limnologist and freshwater copepodologist Bernard Dussart by presenting this contribution in his memory.

March 15, 10:50 (S1-7128)

Climate change in the northern California Current ecosystem: Impacts on the community composition and production of zooplankton

William T. **Peterson**[1], Cheryl A. Morgan[2], Hongsheng Bi[3], Jennifer L. Fisher[2] and Jay O. Peterson[2]

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Climate change may cause changes in ecosystem structure in upwelling ecosystems through physical forcing at two scales: local changes in SST, stratification, hypoxia and upwelling strength, and basin-scale changes in advection associated with basin-scale climate oscillations - PDO, NPGO and ENSO. Here we explore the relative effects of local upwelling vs. basin-scale changes in advection, on copepod community structure in the Oregon upwelling zone using data collected biweekly over the past 15 years off Newport. Using NMDS (ordination) we will show that basin-scale changes in advection in the Northern California Current determine copepod community structure whereas coastal upwelling has its greatest effects on secondary production, not species composition. An hypothesis that may account for these observations is that upwelling has its greatest effect on productivity when the PDO is in cool phase, because a greater proportion of the water feeding the northern California Current is of coastal sub-arctic origin. These waters bring large "northern neritic" copepod species to the upwelling zone of the NCC, species accustomed to handling diatom blooms that typify coastal upwelling ecosystems. When the PDO is positive, a greater proportion of the copepod community is composed of species that are small with offshore warm water affinities. These species may be less able to respond to upwelling because they are unaccustomed to dealing with thick phytoplankton blooms. An understanding of how climate change may affect upwelling ecosystems will require a better understanding of the behavior of the Pacific Decadal Oscillation and associated changes in advection in the NCC.

March 15, 11:10 (S1-7312)

Large changes in zooplankton communities in the Strait of Georgia, British Columbia, during 1990 – 2007

Lingbo **Li**[1], David L. Mackas[2], Brian P.V. Hunt[3], Jake Schweigert[4], Evgeny A. Pakhomov[3], Moira Galbraith[2], John F. Dower[5], Stephen Romaine[2], Deborah Faust[2] and Tony J. Pitcher[1]

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We investigated long-term changes in zooplankton community structure in the Strait of Georgia (SoG), British Columbia, using an 18-year time series collected between 1990 and 2007. Species biomass data collected from the surface 20m in May, June and September were analyzed using multivariate methods (PRIMER package: Non-metric Multidimensional Scaling (MDS) and cluster analysis). Large changes in zooplankton community structure were observed after 2000. SIMPER analysis revealed that the largest changes were in the biomass contributions of euphausiids, jellyfish, and large copepods. Euphausiids dominated zooplankton biomass in the SoG surface waters in September in most years of 1990s after which their biomass decreased dramatically. Jellyfish came to dominate in September in 2000s. Large copepods were dominant in spring, but have declined steeply in the recent period. The surface zooplankton community is compared with that in deep water. We also analyzed environmental variables, including temperature, salinity, freshwater flow and cubic wind speed. The Environmental drivers were identified using the BIO-ENV package and linked changes with changes in the zooplankton communities. We also examine the correlation between zooplankton and fish recruitment. As secondary production plays a key role in food webs, these large changes in the zooplankton community may have had a substantial impact on higher trophic levels and the ecosystem as a whole.

March 15, 11:30 (S1-7136)

Responses of *Calanus finmarchicus* to climate-related changes in phytoplankton bloom dynamics in Northwest Atlantic shelf and sub-polar gyre regions

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Stratification on the Canadian Atlantic continental shelf was higher in the 1990s and early 2000s than in previous decades, mainly because of increased influx of freshwater from the Arctic. On the Scotian Shelf, monthly CPR (Continuous Plankton Recorder) sampling showed that spring diatom blooms occurred earlier in the 1990s and early 2000s than in previous decades, with phytoplankton levels substantially higher between January and March. In *Calanus finmarchicus*, young stages appeared earlier in the year (April *vs.* May), although average annual abundances did not change. Adult *C. finmarchicus* showed no obvious response. In contrast to the Scotian Shelf, stratification in the sub-polar gyre increased in the early 2000s as near-surface temperatures increased markedly over those of previous decades. Here, phytoplankton concentrations increased during the normal growth season, with no major change in the timing of the spring bloom. The response of *C. finmarchicus* was an increase in the abundance of young stages, with no large change in the timing of their appearance, and no change in the abundance or seasonal cycle of the adults. On the Scotian Shelf the change in the timing of the phytoplankton bloom may have led to a partial "mis-match" between peaks of phytoplankton and *C. finmarchicus* production, leading to a greater proportion of the primary production going directly to the benthos. In the sub-polar gyre, however, where phytoplankton levels increased during the normal *C. finmarchicus* growth season, increased phytoplankton production apparently fuelled increased *C. finmarchicus* production.

March 15, 11:50 (S1-7293)

Scenarios of climate change impacts on local production of the subarctic copepod, *Calanus finmarchicus*, in the Gulf of Maine

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The planktonic copepod, *Calanus finmarchicus*, resides at the southern edge of its subarctic range in the Gulf of Maine, where it is a prominent component of the zooplankton community. It produces a lipid-rich, dormant preadult stage in summer. At higher latitudes, the dormant individuals overwinter and molt to the reproductive adult stage prior to the winter-spring bloom in the subsequent year. Using demographic time series data from the Gulf of Maine and an individual-based population dynamics model, we present evidence that temperatures in the Gulf of Maine are too warm to allow *C. finmarchicus* to remain dormant for such an extended period. Instead, many "overwintering" individuals must, for metabolic reasons, break out of dormancy in late summer to late fall. For this fall generation to contribute to the *C. finmarchicus* stock in the Gulf of Maine, it must take advantage of the fall phytoplankton bloom. We present alternate scenarios of consequences of climate change on the regional production. One source of forcing is the alternation between intrusion into the deep Gulf of colder Labrador Subarctic Slope Water and warmer Atlantic Slope Water, influencing duration of dormancy. Another source of forcing is the warming of surface temperatures in late summer, influencing the capacity of *C. finmarchicus* to produce a fall generation. Substantial reduction in abundance or disappearance of lipid-rich *C. finmarchicus* from the Gulf of Maine would arguably have serious repercussions for the functioning of the region's coastal food web, directly impacting the feeding of planktivorous fish, marine mammals, and seabirds.

March 15, 12:10 (S1-7071)

Global relationships between water temperature and vertical distribution of zooplankton

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Localized studies have shown that the decline of zooplankton biomass with depth is relatively steeper in warm than in cold oceans. This trend has been attributed to the accelerated bacterial mineralization of sinking particles in warmer waters, and the consequent decline in food supply to deep layers. In this study, we analyzed the vertical distribution of epipelagic zooplankton (>100µm) in 163 published day/night profiles collected since 1949 around the globe, covering a range of average temperatures from -2°C to 28°C in the upper 100m layer. For each profile, we calculated the ratio between the biomass of zooplankton in the upper 100m and that in the 100-200m layer. The results show a strong relationship between the biomass ratio and the mean temperature of the upper 100m, with the regression line having a significant positive slope of 0.03 (R^2=0.58). This relationship was stronger (higher R^2) for night than day profiles, likely due to the deep residence during the day of vertically migrating zooplankters, which consume food in the upper layer at night. Our findings suggest that in warming oceans, a decline in zooplankton biomass is expected at depth even without a change in zooplankton biomass in the upper waters. This effect of global warming is likely to cascade to the deep sea, as has already been observed for some benthic communities.

March 15, 14:00 (S1-7153)

Mesozooplankton in the Aegean Sea (E.Mediterranean Sea): Differences among decades

Ioanna **Siokou-Frangou**[1], Maria-Antonietta Pancucci-Papadopoulou[1], Dionysios Raitsos[1], Alex Theocharis[1], Vassilis Zervakis[2] and Soultana Zervoudaki[1]

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The Aegean Sea's mesozooplankton abundance and species composition were compared among several decades (mid 1960s, late 1980s, 1990s and 2000s). Late winter-early spring mesozooplankton abundance values increased from the 1980s to the 1990s and even more in the late 2000s. Satellite-based chlorophyll estimates also increased in the 2000s. In the North Aegean, the increase in chlorophyll could be due to changes in the incoming waters from the Black Sea and/or to local vertical mixing, depending on the local climatology. In the South Aegean, winter vertical mixing probably enriched the euphotic layer with nutrients of the Transitional Mediterranean Water, which entered the area in late 1980s during the Eastern Mediterranean Transient (EMT) (1987-1994), a climatically driven event, and in the post-EMT period (1995-2006)The contribution of *Clausocalanus* spp. (mainly *C. pergens, C. paululus, C. furcatus*) has increased since the late 1980's, occupying the first or second rank in spring in the North Aegean and in late summer in both the North and South Aegean. Similarly, the rank of *Oithona* spp. (mainly *O. plumifera, O. setigera, O. similis*), *Calocalanus* spp., Oncaeidae and Corycaeidae became higher in the 1980s, 1990s and 2000s. In the latter decades, *Temora stylifera* had a lower rank in the South Aegean during the warm period, and it was very rare in the cold period, whereas it was the most dominant species in both areas in the 1960s. The observed changes correspond to the increasingly sub-tropical character of the mesozooplankton community, in accordance with the tropicalization of the Mediterranean Sea.

March 15, 14:20 (S1-7252)

Changes in community structure, trophic links, and phenology in a lower trophic level ecosystem in the western subarctic North Pacific during 2001-2009

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We investigated interannual variation of lower trophic level ecosystem structure in the western subarctic North Pacific (40-55°N, 142-170°E) using phytoplankton and zooplankton samples collected by Continuous Plankton Recorder (CPR) survey during 2001-2009, with focus on ecosystem responses to large scale climatic forcing, *e.g.* Pacific Decadal Oscillation. We found that during this period, abundances of diatoms and copepod nauplii were highest in 2001, and both gradually declined toward the late 2000s. Analysis of satellite ocean color data indicated that annual phytoplankton abundance was highest in 2001, and timing of spring bloom was shifted later by approximately one month between 1998 and 2006. Previous studies reported a gradual decline in oceanic CO_2 uptake in this region and an increase in the ratio of $CaCO_3$ to biogenic opal in deep-sea sediment trap samples. Contrary to phytoplankton phenology, developmental timing of two dominant copepod species, *Neocalanus plumchrus* and *Eucalanus bunjii*, became earlier from the early to late 2000s, with a marked shift around 2002-2004. The delayed spring bloom might benefit the production and development of these summer species. The possible links between these changes in plankton community structure, phytoplankton and zooplankton phenology, and biogeochemical processes will be discussed in the presentation.

*This study is being conducted as the part of North Pacific CPR program.

March 15, 14:40 (S1-7190)

Long-term hydroclimate drivers of zooplankton composition and phenology off eastern Australia

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Plankton responds rapidly to changes in ocean climate, making it an invaluable indicator of ecosystem health and climate change. Australia is depauperate in oceanographic time series, and the longest zooplankton time series from Australian waters is only 2 years in length. The east coast of Australia is influenced by the East Australian Current, a warm, poleward-flowing western boundary current. This current has increased in strength by 25% over the past 60 years. Here we describe the composition, abundance and seasonal cycle of the zooplankton community from monthly sampling from 2002-2010 off Sydney (100 m depth) and compare it with historical data. Multivariate analyses show distinct coastal and oceanic zooplankton communities related to hydroclimatic conditions. We find that many functional groups and species exhibit phenological changes in peak abundance associated with water temperature. However, understanding the environmental drivers of zooplankton variability is challenging because of the intense eddy activity in the region. To assess the potential effects of climate change on lower trophic levels in the region, we then compare zooplankton data from 2002-2008 with historical qualitative information collected in the 1930s and 1940s. This study represents the longest zooplankton dataset in Australia, and it is one of nine reference stations that are part of the Integrated Marine Observing System in Australia.

March 15, 15:00 (S1-7076)

Late 1980s regime shifts: Intriguing parallelisms in European (and other) seas

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Statistical analyses of copepod community data in the Gulf of Trieste indicate several changes in the late 1980s, possibly related to changes in circulation and to a general warming of the area. Extension of these analyses to other components of the trophic system show step changes in these too, and also in the western basin. A literature survey indicates that the Mediterranean circulation underwent a change in this period. The combined evidence suggests a regime shift (meaning, an abrupt change in biotic and abiotic properties) in the Mediterranean Sea in the late 1980s. A comparative analysis of the literature reported in other basins (North Sea, Baltic Sea, Black Sea) shows a similar pattern in all European Seas during the same time. Other studies suggest that similar shifts are present during this period in other basins (*e.g.*, Pacific), leading to the hypothesis of a larger, hemispheric phenomenon. Future work includes comparative analysis of synchronous regime shifts in different regions, since these may provide the key for distinguishing local (*i.e.*, basin) anthropogenic drivers, such as eutrophication or fishing, from larger scale (*e.g.*, hemispheric) climate drivers.

March 15, 15:20 (S1-7229)

Regional scale climatological forcing of *Calanus finmarchicus* dynamics in the Gulf of Maine and the Gulf of St. Lawrence

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A synoptic climatology was developed to capture dominant modes of daily weather variability affecting the Gulf of Maine and the Gulf of St. Lawrence from 1950-2010. We found 8 dominant weather patterns visualized as sea level pressure maps. Using monthly frequencies of weather pattern occurrence, we found that the same patterns forced surface conditions in both locations. Surface air temperature and dominant wind modes as well as sea surface temperature and salinity were strongly correlated to changes in weather pattern frequency. In contrast, the North Atlantic Oscillation showed weak to no relationship between surface conditions. Analysis of *Calanus finmarchicus* variability revealed that years with similar *C. finmarchicus* abundance clustered together by region and those years were correlated with weather pattern variability. This analysis suggests that a regional scale climate approach to climate classification is a more useful tool to describe biological variability over shorter time scales than larger scale indices, such as the North Atlantic Oscillation (NAO). Synoptic climatological modes can also be used to relate interannual variability in climate forcing to critical life-history periods for *C. finmarchicus*, such as exit and entry into dormancy, that do not occur in months that are affected by the NAO.

March 15, 15:40 (S1-7091)

How do organisms change size with changing temperature? Exploring the mechanism of the Temperature-Size Rule

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Changes in phenology and shifts in species' range are widely recognised as outcomes of environmental warming. However, a third ecological rule exists that is widely observed yet poorly understood, the Temperature-Size Rule (TSR). The TSR refers to how, within an ectothermic species, higher rearing temperatures lead to decreased size at a given developmental stage. This rule has been shown in over 80% of species, including bacteria, protists, plants, invertebrates and vertebrates. Changes in body size have importance implications in aquatic systems, for example, predator-prey interactions are size-dependent. However, there is debate over the mechanism underlying the TSR; one proposed explanation has been that growth and development rates have different temperature dependence. We have developed a conceptual model in order to understand how organisms change size with changing temperature. This highlights fundamental differences between uni- and multicellular organisms; in the former, binary fission sets critical restrictions. Multicellular organisms have a greater range of options. Only if the ratio of sizes of progeny to adult changes can they maintain differences in the temperature dependence of growth and development rates: unicells lack this potential. Performing a meta-analysis on aquatic and terrestrial ectotherms we find clear evidence for this, adult size changes more radically than progeny size (*e.g.* in cladocerans, copepods and rotifers). Finally, we use data on marine copepods to rigorously test whether growth and development show different temperature dependence. We find these rates to be decoupled, showing fundamental differences in the mechanism of the TSR in uni- and multicellular organisms.

March 15, 16:30 (S1-7032)

Long-term changes in the distribution and abundance of selected fish larvae from the CPR (1950-2005) over the UK shelf, in relation to biological and environmental factors

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The Continuous Plankton Recorder (CPR) survey is a unique and well known source of long-term and large-scale information covering more than 300 species of zooplankton. Fish larvae are also sampled by the CPR but their routine identification stopped after 1978. However, the visual identification of separate species or families in historic CPR larval samples covering the period 1979-2005 has now been completed. The most abundant groups of fish larvae caught by the CPR are Clupeids (*Clupeidae*), Sandeels (*Ammodytidae*) and Atlantic Mackerel (*Scomber scombrus*). Here we explore the biogeographical changes in fish larvae distributions over the 55 years of data available (1950-2005) as well as the potential relationships over the UK shelf with prey abundance (*copepods* and *cladocerans*), phytoplankton (*diatoms* and *dinoflagellates*) and environmental variables. We further examine the potential relationships of Clupeid larvae with the stock assessment data for Herring (*Clupea harengus*) in the North Sea and Celtic Sea.

March 15, 16:50 (S1-7320)

Jellyfish outbreaks in the Mediterranean Sea unveil synergies of climate and fisheries

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Jellyfish outbreaks are ubiquitous across marine ecosystems. Recent reports, however, have documented long-lasting high abundances and associated economic damages. Yet, the specific causes and mechanisms remain vague, although in a changing world ocean their understanding is crucial for a sustainable management of marine resources. Here we test three competing hypothesis to explain the long term dynamics in the Mediterranean Sea, and show that the growing jellyfish abundances unveil synergistic effects of increasingly warmer waters and competition and predation release. Such synergies have manifested as enhanced frequency and larger variability of jellyfish bloom cycles in the last decades in the Mediterranean Sea. These findings stress that ignoring the compound effects from climate changes and fishing will impair a prudent management in the already threatened Mediterranean Sea.

March 15, 17:10 (S1-7007)

Zooplankton response to NW Mediterranean hydroclimatic changes from 1966 to 2010

Pieter Vandromme[1], Lars **Stemmann**[1], Carmen García-Comas[2], Laure Mousseau[1], Franck Prejger[1], Ornella Passafiume[1], Marc Picheral[3] and Gabriel Gorsky[3]

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Previous time series analysis on different components of the plankton communities in the North Western Mediterranean Sea highlighted the correspondence between changes in the abundance and/or composition of some target species and the shift in the local climate that occurred in the late 1980's. More specifically in the Ligurian Sea, earlier studies, presenting data on target species from 1966 to 1993, suggested that jellyfish would out-compete chaetognaths and be detrimental to copepods, the abundance of which dropped from the late 1980's to 1993. Warming was suggested to lead to oligotrophy of the pelagic ecosystem and to favour jelly plankton. In the frame of the monitoring program carried out by the Laboratory of Oceanography at Villefranche sur Mer, we pursued until 2010 the analysis of zooplankton samples. In order to study different plankton size classes, we used the WP2 (mesh size of 200 µm) and the Juday Bogorov (mesh size of 330 µm) nets. Samples were analysed using the Zooscan, which allows plankton changes to be studied at the community level and also in the size spectra. Results showed that total copepods and chaetognaths recovered to almost the abundance of the 1980's in the late 1990's, while jellyfish remained abundant. Despite rising annual temperatures, the Ligurian planktonic ecosystem has not yet shifted to an oligotrophic state dominated by jelly plankton. Combining the updated zooplankton time series with climatic, hydrological and biogeochemical data from the monitoring station, we will suggest possible mechanisms by which climate changes trigger seasonal, decadal and long term changes in the pelagic ecosystem in the NW Mediterranean Sea.

March 15, 17:30 (S1-6904)

Scyphozoan jellyfish trends during 1992-2010 at Flødevigen, Southern Norway

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While a global increase in jellyfish abundance due to human influences is frequently stated, long term data supporting this claim remains scarce. We have examined a 1992-2010 time series on *Cyanea* spp. and *Aurelia aurita* abundances at Flødevigen Research Station (southern Norway) for long term trends and influence of environmental variables (monthly mean temperature and salinity, 20 m depth at Lista). Since *Cyanea* spp. both preys on and competes with *A. aurita,* we also looked for evidence of species interactions. Several variables describing annual abundance and seasonal timing were significantly correlated within species but generally not between species. However, comparison of weekly mean abundance anomaly time series suggests that extreme abundances of *A. aurita* and *Cyanea* spp. are mutually exclusive. There was a significant decreasing trend for many annual abundance variables for *A. aurita* but no significant trends for *Cyanea* spp. Temperature and salinity in February had a significant negative correlation with the timing of the *A. aurita* season. Salinity in February was significantly correlated with several *Cyanea* spp. variables, with high salinities associated with early, long and abundant *Cyanea* seasons. Temperature in the preceding October-November correlated significantly with several *A. aurita* variables, with higher temperatures associated with later, shorter and weaker seasons. These correlations with environmental variables coincide with known strobilation periods for *C. capillata* and *A. aurita* and may reflect environmental influences on the production of ephyrae. Our results illustrate the importance of considering regional differences when discussing trends in jellyfish abundances.

Session 2 Oral Presentations

March 15, 8:35 (S2-6988), Invited

Acquired phototrophy in ciliates: Does it boost trophic transfer to mesozooplankton?

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Many planktonic ciliates in the euphotic zone are mixotrophs due to acquired phototrophy and have higher gross growth efficiencies than strictly heterotrophic microzooplankters. We estimated the boost from acquired phototrophy to trophic transfer from phytoplankton to mesozooplankton in the SE Bering Sea in summer. During summer stratification, chlorophyll was low (<0.5 micrograms l^{-1}) and microzooplankton biomass was ~ equal that of phytoplankton near the coast and on the middle shelf. Ciliates and heterotrophic dinoflagellates dominated the 20-200 micron size fraction. Mixotrophs dominated the ciliate biomass. When chlorophyll is low, ciliates comprise ~ 50% of the diet of copepods (Calbet & Saiz, 2005). Based on gross growth efficiencies (reviewed in Stoecker *et al.* 2009) and contribution of mixotrophic ciliates to plankton biomass on the Bering Sea Shelf, we estimate that acquired phototrophy boosted trophic transfer of carbon from phytoplankton to copepods by ~7% during summer in coastal and middle shelf waters. On the outer shelf and in upwelling areas, where large cell size phytoplankton were more abundant, we estimate that acquired phototrophy had little impact (≤1%) on trophic transfer to mesozooplankton. Microzooplankton, and mixotrophic ciliates in particular, are often dominant components of the microplankton in high latitude coastal and shelf ecosystems during summer (reviewed in Stoecker *et al.* 2009). The role of the microzooplankton link, and the importance of plastidic ciliates in particular, in the diet of zooplankton may increase if climate change causes more seasonal stratification in high latitude seas.

March 15, 9:00 (S2-7072)

Plankton trophic structure and food-web fluxes in the eastern equatorial Pacific

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Although evidence exists for decadal-scale variations in chlorophyll, primary production and/or zooplankton biomass in many regions of the open oceans, we generally lack sufficient understanding of trophic structure and food-web fluxes to evaluate differences within and among systems or to serve as baselines for documenting and predicting effects of future climate changes. For the eastern equatorial Pacific, a large and globally significant player in ocean-atmosphere carbon cycling, we illustrate how the results of experimental process studies have been combined with inverse modeling to examine some of the details of plankton trophic pathways. The results provide well-constrained estimates of the partitioning of production and fates of major phytoplankton taxa, how fluxes are distributed with depth in the euphotic zone, the relative grazing roles and coupling between micro- and mesozooplankton, and the secondary production generated by food-web flows.

March 15, 9:20 (S2-6989)

Projections of changes in the spatial distribution of zooplankton for the end of this century: Consequences for higher trophic levels

Sylvain **Lenoir**, Grégory Beaugrand and Jean-Claude Dauvin

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Climate change is unambiguous and its effects are clearly detected in all functional units of the Earth System. Changes are seen from phytoplankton to zooplankton to fish and are modifying the dominance of species and the structure, diversity and functioning of marine ecosystems. Climate changes have implicated strong biogeographical shifts in the North-East Atlantic. These alterations reflect a response of pelagic ecosystems to a warmer temperature regime. Mechanisms are complex because they are nonlinear, exhibiting tipping points and varying in space and time. Sensitivity of organisms to temperature changes is high, indicating that a small temperature modification could have sustained ecosystem effects.

In this talk, we present scenarios of future spatial distribution of some key zooplankton species in the North Atlantic. Projections of change in zooplankton distributions suggest major modifications that could exceed 10° of latitude by the end of the century. Scenarios of changes vary according to species, the intensity of warming, and the ocean-atmosphere general circulation model used. However, they indicate potential major reorganisation of biological systems for the end of this century. We then discuss how changes in the spatial distribution of zooplankton may influence higher trophic levels, using the example of the Atlantic cod *Gadus morhua,* and show that the absence of consideration of zooplankton in the models might strongly affect predictions of changes in the spatial distributions of higher trophic level populations.

March 15, 9:40 (S2-7103)

Impacts of introduced copepods on the growth and survival of planktivorous fish in the San Francisco Estuary

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Populations of planktivorous fish in the San Francisco Estuary (SFE) are in a state of decline. Declines in some species have been correlated to changes in the abundance and distribution of their zooplankton prey. Over the past two decades, there has been a shift in the species composition of zooplankton from a community dominated by calanoid copepods to one dominated by a single introduced cyclopoid copepod, *Limnoithona tetraspina*. Since its introduction, *L. tetraspina* has become the most abundant copepod in the SFE, at times outnumbering all other copepods by a factor of ten. Because *L. tetraspina* is significantly smaller than the historically dominant calanoid species (*Eurytemora affinis* and *Pseudodiaptomus forbesi*), there has been a corresponding decline in the accessibility and biomass of appropriately sized prey. To examine the impact of prey assemblage changes on growth and survival of planktivorous fish, we conducted long-term rearing trials with first-feeding (6-day-old) and 30-day-old delta smelt (*Hypomesus transpacificus*). Each age-group was reared for 30 days on one of three diets: *L. tetraspina* (cyclopoid), *P. forbesi* (calanoid), or a control diet (rotifers and *Artemia* sp.). Each prey type was offered in excess but at relative densities similar to those observed *in situ*. Both age-groups grew larger on a per-carbon basis when fed *P. forbesi*; however, larval survival did not differ significantly among diets. This information supports claims that *L. tetraspina* provides suboptimal nutrition for delta smelt, and that shifts in prey composition may be contributing to the decline of pelagic organisms in the SFE.

March 15, 10:30 (S2-7067)

Spatial variability in lipid content and fatty acid profiles of macrozooplankton from coastal British Columbia, Canada

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Pacific salmon are a staple economic and cultural resource in British Columbia, and variable food quality may play a major role in their production through impacts on growth and overwinter survivorship during their first year at sea. Recent development in the use of fatty acids as bioindicators have drawn attention to the importance of food quality and nutritional value in the productivity of marine ecosystems. There is growing evidence that prey quality may be as important as prey abundance in transferring energy through food webs. The concentrations of polyunsaturated fatty acids, such as eicosapentaeonic acid (EPA) and docosahexaeonic acid (DHA) within an organism, have become popular proxies for estimating food quality. Here we examine spatial variability in fatty acid profiles, as well as overall lipid content, across a range of zooplankton species commonly found in coastal British Columbia, Canada. Selection of target species, which included copepods, amphipods and euphausiids, was motivated by their prevalence across a wide area, ease of capture and importance in the diet of juvenile salmon. Samples were collected from bongo tows at more than 100 locations in the waters surrounding Vancouver Island and in more Northern coastal areas between May and September 2010, allowing for intraspecies comparisons over multiple spatial scales. Variability across ecosystems in the presence of critical fatty acids could create major inconsistencies in the efficiency of energy transfer to higher trophic levels, particularly to juvenile salmon.

March 15, 10:50 (S2-7191)

Long-term variation of the plankton community in the Kuroshio warm current area; the spawning ground of Japanese sardine

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The Kuroshio warm current area off the southern Japan archipelago is one of the most important fishery research areas in Japan, because the inshore area of the Kuroshio is known as a main spawning field and nursery ground for early juveniles of Japanese sardine. Large scale, long term variations of the stock size of sardine have been clearly observed, and such variations are thought to be related to the variation of biological productivity in the area. Since the late 1980s, the stock size of Japanese sardine has been extremely low compared to previous decades.

The Japanese Fishery Research Agency has been monitoring the oceanic environmental conditions around Japan for fishery research. The seasonal variation of biological productivity has been clearly established. The spring phytoplankton bloom occurs every year after stratification of the upper layer occurs in spring. Since the spawning season of Japanese sardine is between late winter and early spring, the spring bloom seems to be important factor for the feeding condition of early hatched larvae of sardine. The annual variation of biological productivity in the area has also been studied. One of the causes of the annual variation is thought to be the variation in the meander pattern of the Kuroshio warm current. Here, we present the seasonal and annual variation of the biomass and timing of the spring phytoplankton bloom, and of the biomass and size composition of zooplankton in the Kuroshio area, and discuss them in relation with variations of the sardine stock size.

March 15, 11:10 (S2-7137)

Zooplankton prey species and foraging ecology of bowhead whales (*Balaena mysticetus*) in the Canadian High Arctic: Insights from stable isotope and stomach content analyses

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The Eastern Canada-West Greenland (EC-WG) bowhead whale (*Balaena mysticetus*) population is slowly recovering from the commercial whaling of the 19th and 20th centuries. However, bowhead whales are still at risk of extinction because of a combination of biological characteristics (*e.g.*, low natural growth rate and long interbirth interval) and identified threats (*e.g.*, climate change, predation, human activities). The analysis of stable isotope ratios, particularly those of carbon and nitrogen, in tissues of predators and their prey is a tool commonly used in feeding ecology to study trophic structure of ecosystems. In this study, our objective was to identify the main prey species and diet composition of the bowhead whale. We examined the foraging ecology of bowhead whales by comparing stable carbon and nitrogen isotopes ratios of whales (n = 200) with those of various potential zooplankton prey species collected across the Canadian Eastern Arctic, including the Labrador Sea, Davis Strait, Baffin Bay and the Archipelago. Stable isotope ratios varied between zooplankton species as well as spatially within species. A bayesian stable isotope mixing model (SIAR) was used to calculate the proportional contributions of various sources (zooplankton) to the diet of bowhead whales. These results were compared to stomach contents from four bowhead whales harvested between 1994 and 2008 from the Canadian Arctic. The latter indicated a diet, which varied from being constituted exclusively of pelagic species with *Limnocalanus macrurus* as the main prey, to ones including epi-benthic and benthic species, with *Mysis oculata* playing an important role.

March 15, 11:30 (S2-7218)

Acoustic study of the macrozooplankton community in the Bay of Biscay: Diel vertical migration, spatial patterns and interaction with pelagic fish

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Macrozooplankton, and in particular euphausiids, play a key role in ecosystems as a link between lower trophic levels and fish. However, its role is usually considered in polar ecosystems and neglected in temperate ones. As an example, in the Bay of Biscay, mesozooplankton and commercial fish are routinely studied, but the biomass and distribution of macrozooplankton is unknown. Due to avoidance, macrozooplankton is difficult to catch using classic net sampling methods. To obtain comprehensive information on macrozooplankton in the Bay of Biscay, we adapted a bi-frequency acoustic method developed in the Humboldt Current system. This method allows for the extraction of continuous and simultaneous high-resolution information on the spatiotemporal patterns of macrozooplankton and pelagic fish biomass distributions. Both distributions were mapped using geostatistical techniques. In particular, we applied a kriging with external drifts that accounts for both diel and across-shore changes in macrozooplankton biomass. We then used log-backtransformed cross-variograms to investigate the scale-dependent relationships between macrozooplankton and fish. Results showed how macrozooplankton distribute according to the different ecological domains (river plumes, coast, shelf, shelf break and offshore). We observed specific hot spots of macrozooplankton, but in general it was more abundant offshore than inshore, while fish presented an opposite trend. This pattern was confirmed by the size of the aggregations, which increased towards oceanic waters for macrozoplankton and decreased for fish. Finally, we observed that the correlation between fish and macrozooplankton was positive at small scale (~20nm) and negative at a regional scale (~60nm).

March 15, 11:50 (S2-7319)

Aggregation of euphausiids and interaction with higher predators in regions of abrupt topography of the northwest Atlantic

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Large aggregations of euphausiids are often observed in regions of abrupt topography such as continental shelf breaks and submarine canyons. Understanding the biological and physical factors that lead to such aggregations is an important problem as these regions also often constitute key habitat for a number of top predators, including commercial fishes, seabirds, and cetaceans. A series of three cruises were conducted in July, September, and October of 2010 to the margins of Georges Bank to characterize along- and across-slope variability in the distribution of euphausiids and other zooplankton, their predators, and the biological and physical environment. A combination of coarse-scale mapping and fine-scale adaptive surveys were used to identify and track individual euphausiid aggregations and to observe how their three-dimensional structure and vertical position varied with changing conditions. Zooplankton was sampled with a novel broadband acoustic system, a multi-frequency acoustic system, a video plankton recorder, and a MOCNESS. These cruises represent among the first use of the broadband technology for the study of zooplankton ecology. Concurrent to zooplankton sampling, visual observations were made of the distribution and behavior of seabirds and marine mammals. The surveys capitalized on natural variation in predation levels and predator types by targeting both canyon and non-canyon regions, and times when predators were expected to be feeding and not feeding on euphausiids. Distinct spatial and temporal variability was observed in euphausiid abundance, patch structure, and community composition, along with changes in the abundance and distribution of higher predators.

March 15, 12:10 (S2-7022)

The functional biology of krill (*Thysanoessa raschii*) with focus on its ecological role in a Greenlandic fjord

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Despite their prominent role in the food web, krill biology has received surprisingly little attention in the Arctic. This study focus on the trophic role of krill along a transect from offshore waters into the Godthåbsfjord, Southwest Greenland, examined by a combination of fieldwork and laboratory experiments. Krill were not present in the offshore area but dominated the zooplankton biomass in the fjord. *Thysanoessa raschii* was the most abundant euphausiid species, and was used in various feeding experiments on phytoplankton cultures and natural seawater. *T. raschii* showed a Holling type III functional response when fed with the diatom *Thalassiosira weissflogii* and had a daily ration of 1% d^{-1}. During the experiments with natural seawater, *T. raschii* was capable of exploiting plankton cells in the size range 5-400µm, covering several trophic levels of the pelagic food web. The calculated *in situ* grazing impact by *T. raschii* on the standing stock of the plankton community was negligible. However, in reality the schooling and migratory behavior of krill will make their grazing impact patchier and therefore correspondingly much higher within the euphotic zone. In conclusion, this study contributes with new knowledge about krill and its role in the pelagic food web, essential for understanding the ecosystem dynamics in the Arctic areas.

March 15, 14:00 (S2-7327)

Phytoplankton ingestion by populations of dielly migrating copepods and euphausiids in Dabob Bay, a coastal fiord in Washington, USA

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Fiords in western North America typically contain large populations of dielly migrating zooplankton. In Dabob Bay, zooplankton was sampled during three or four 24 hr cycles on month-long cruises in spring, summer and autumn. The most abundant diel migrators were *Calanus pacificus* and *Euphausia pacifica*. Subsamples were analyzed for gut-content of phytoplankton pigments, which were used to determine ingestion rates of phytoplankton. Population ingestions rates were determined for each diel migrator, and whole community rates were compared to measurements of primary production made every 2 days and chlorophyll measured every 6 hr. Primary production (PP) was highest in March, intermediate in May and lowest in October. Total community grazing was about 25% PP d^{-1} in March and May, and >50% in October when zooplankton populations (especially euphausiids) were highest and PP was lowest. Further evidence for a strong grazing impact by this zooplankton was provided by a diel signal in chlorophyll concentration. Also, previous work by others has shown a daily cycle of sinking fecal pellets. Non-migrating mesozooplankton (primarily *Oikopleura*) also appeared to be important consumers of phytoplankton in all three study-periods. Fiords like Dabob Bay are unique environments that support high transfer between phytoplankton and mesozooplankton for several reasons: they are productive, with frequent blooms of diatoms and other large cells; large cells are ideal foods for mesozooplankton; and water depth is sufficient to provide a day-time refuge for large bodied dielly-migrating mesozooplankton with high feeding rates, like *C. pacifius* and *E. pacifica*.

March 15, 14:20 (S2-6932)

Seasonal variability of feeding and reproductive activity of the copepods *Drepanopus forcipatus* and *Calanus australis* in the Southern Patagonian Shelf: Post-bloom *vs.* early-bloom conditions

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The copepods *Drepanopus forcipatus* and *Calanus australis* are key species in the plankton communities of the Southern Patagonian Shelf, together constituting most of the mesozooplankton biomass. However, their life strategies in relation to seasonal changes in food availability are poorly known. In late summer after the spring bloom, phytoplankton abundance has diminished and food availability in the size fraction mainly grazed by copepods (>10µm) is low, while in early spring food conditions are comparatively much less limited. This study compares the feeding and reproductive activities of both copepods during those two distinct food scenarios and examines the interactions between feeding and reproduction. To address this question, an index of feeding activity was measured, the gut contents were inspected, and the gonad stages were determined on the same specimens in both species. As expected, feeding and reproductive activity were markedly higher in early spring than in late summer for both species. Both copepods showed similar levels of feeding and reproduction in early spring, while during late summer feeding and reproduction were higher in *Drepanopus forcipatus* than in *Calanus australis*. The results will be discussed in relation to the particular strategies developed by these copepods to overcome food limitation (prey selection, compensatory feeding, diapause) and their effects on the life cycle and population dynamics.

March 15, 14:40 (S2-7148)

Zooplankton and algal blooms – Case studies from the Baltic

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Interactions between zooplankton and toxic blooms can be more complex than expected. Our experiments examined grazing, survival, and short-term growth responses of the copepod Eurytemora affinis in relation in harmful algal blooms. We also measured growth and toxin production of the cyanobacteria Nodularia spumigena in the presence of rotifers and the copepod. In treatments with copepods, intracellular nodularin were up to four times lower than in the copepod-free treatments. Growth of algae was also positively affected. This could be because copepods preferred more edible algae as food, and thereby removed potential competitors of the toxic algae. Copepods, in general, fed actively on cyanobacteria, measured as DNA in their stomachs, but cyanobacterial DNA was detected at higher frequency when other food was low in availability. In all experiments with copepods, survival in the presence of toxic cyanobacteria was high, suggesting high tolerance to the toxin nodularin. Short-term growth, measured as RNA in copepods, was also high in incubations with *Nodularia*, revealing no noxious effects by toxic algae on copepods growth status. To conclude, copepods seem to lower toxin levels in *Nodularia*, which is quite opposite to what has been found with other cyanobacteria. Copepods are also well adapted to locally and temporally occurring blooms.

March 15, 15:00 (S2-6957)

Diet composition and food selectivity of Sprat (*Sprattus sprattus*) in Hardangerfjord, a fjord off western Norway

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Sprat (*Sprattus sprattus*) is a small-bodied pelagic schooling zooplanktivorous fish, which plays a major role in the fjord ecosystems, both as an important food resource for higher, piscivorous trophic levels and as a significant predator on the zooplankton community. The seasonal and size-dependent diet composition and selection of sprat were studied in the Hardangerfjord. Four cruises were performed in spring (April) and autumn (November) in 2009 and 2010. The diet of sprat was dominated by zooplankton, mainly the copepods *Acartia, Temora,* and *Oithona* spp. Larger sprat had a higher proportion of *Pseudocalanus* spp. and *Calanus* spp. Additional food sources of sprat were phytoplankton, meroplankton, harpacticoid copepods, and euphausiid eggs. During spring, phytoplankton and meroplankton were a conspicuous part of the diet. Large geographical differences in diet were observed along the fjord axis, reflecting the variation in zooplankton composition within the fjord. Despite a general increase in zooplankton biomass towards the mouth of the fjord, the highest abundances of sprat were recorded in the inner areas. Diet composition and selection are discussed in relation to within-fjord variations in zooplankton composition and predation risk.

March 15, 15:20 (S2-7182)

The effect of contrasting feeding environments on anchoveta egg quality during the spawning season off central Chile

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Historically, environmental change effects on adult reproductive fishes have been observed as variations in somatic growth, lipid accumulation or reproductive output (fecundity). Less attention has been given to changes in the quality of eggs produced under different feeding environments and the subsequent survival of offspring. In this study we assessed the fatty acid (FA) composition and other indicators of egg quality of anchoveta eggs along with female anchoveta reproductive traits in response to contrasting environmental conditions (hydrography and food web structure) during the peak winter spawning seasons in 2005 and 2007 off Talcahuano. The environmental conditions in winter 2005 included a warmer and fresher water column than in 2007, which resulted from a rainy season induced by the typically dominant north winds. The winter 2005 mesozooplankton was dominated by typical small omnivorous and carnivorous copepods (*Oncaea* and *Oithona*). In contrast, in 2007, larger herbivorous Calanidae copepods (typical of upwelling conditions) and diatoms were more abundant. Also in 2007, the relative amount of polyunsaturated fatty acids (PUFA) in the eggs was in the upper range of reported values in the literature. Our results indicate that the higher PUFA and lower DHA/EPA values of anchoveta eggs in 2007 may have resulted from increased consumption of larger herbivorous copepods or direct consumption of larger phytoplankton (both rich in PUFA). Because fatty acids composition affects egg and larval development, our results suggest that inter-annual variability in environmental conditions affecting the female reproductive output may lead to differences in egg quality that ultimately modify the chances of the offspring survival of small pelagic fishes.

March 15, 15:40 (S2-7004)

Biotic *vs.* physical control of zooplankton in estuaries

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Estuaries can be challenging environments, with their sharp gradients and strong physical forcing. One would expect that zooplankton – at the mercy of tidal and residual flows – would be particularly sensitive to the physical dynamics of estuaries. Yet, though the physical demands of estuarine life impose constraints on the zooplankton that can live there, biotic controls more often drive distributions and dynamics within estuaries. For example, low diversity is characteristic of estuaries regardless of salinity regime or productivity, and factors such as predation may be as important as salinity and eutrophication in constraining diversity as well as species and size composition of zooplankton. Food limitation of zooplankton is common in estuaries; many instances of population collapse due to predator outbreaks have been reported. Less commonly reported, but probably ubiquitous, are instances of continual, substantial mortality by parasitoids and by predaceous zooplankton, fish, and benthos. Such predation can strongly influence species and size competition. Zooplankton have various mechanisms for coping with estuarine conditions including small size, tidal migration, demersal behavior, and ways of escaping poor conditions such as resting eggs and other spatial and temporal refuges. Thus, in considering the effects of long-term change such as climate, it is necessary to look beyond simplistic considerations of physiology and tolerance. Ecological consequences of climate change can include biotic interactions that cascade up and down the foodweb, as well as local invasions and extirpations. Comparative analysis among estuaries and across zooplankton taxa may highlight the relative roles of biological and physical influences on the responses of estuarine zooplankton to long-term change.

March 15, 16:30 (S2-7048)

Measurements of zooplankton preyfield densities over small spatial and temporal scales and their effect on the behavior of individual baleen whale predators

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In order to assess and understand the behavior of marine mammals, it is important to measure factors which might influence their behavior such as food abundance and distribution. Multiple frequency acoustic backscatter, net tow, and video data were used to measure the abundance and distribution of zooplankton (and nekton) prey in Cape Cod Bay and the Antarctic Peninsula during Spring 2010 over small temporal (hours) and spatial (meters to kilometers) scales. These measurements were made near to and around tagged right (in Cape Cod Bay) and humpback (both locations) whales. The tag data provide information about the depth and movement of the whales such that the preyfield and predator positions could be georeferenced to each other. Acoustic scattering models were used to convert acoustic backscatter data to estimates of numerical density of prey (copepods, krill, or fish). These were then compared with the distribution and behavior of the baleen whales. Whale behavior differed between the right and humpback whales in Cape Cod Bay and between humpback whales in temperate and polar locations. These differences were related to differences in the distribution and abundance of the whale's preferred prey.

March 15, 16:50 (S2-7025)

Resolving the small scale distribution of plankton and marine snow: Unravelling the role of thin layers as assessed with optical techniques

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Aggregates of biogenic origin (known as marine snow) play a major role in the ocean's particle flux, and may represent a concentrated potential food source for zooplankton. For example, laboratory experiments have verified that a number of zooplankton species feed on marine snow particles, even if phytoplankton prey are available in the water column. However, due to the destructive nature of conventional net tow sampling methods, and their inability to resolve small-scale spatial distributions, a paucity of field evidence for this potentially important foodweb link still exists. We used a non-destructive underwater video device, the Video Plankton Recorder (VPR), to assess the overlap between zooplankton and thin layers of marine snow. Critically the VPR allows qualitative and quantitative sampling of these fragile aggregations as well as plankton and particles on appropriate scales.

Our results show a pronounced overlap between marine snow and zooplankton organisms in thin layers located along hydrographic discontinuities and steep vertical gradients during late phytoplankton bloom conditions in the Baltic Sea. We provide in-situ evidence of the potential for trophodynamic interactions due to the strong spatial overlap.

This link between food web dynamics and particle flux identified here is still lacking in detail, in particular due to the inability to assess these interactions with conventional sampling approaches. We suggest that future research activities should focus on trophodynamic interactions in these understudied and potentially key feeding environments of marine zooplankton.

March 15, 17:10 (S2-7070)

The role of *Noctiluca scintillans* in the trophic dynamics of the Black Sea plankton community

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The heterotrophic dinoflagellate *Noctiluca scintillans* is a common member of the zooplankton community in the Black Sea. Due to its wide food spectrum, *N. scintillans* can affect the plankton community in different ways during the periods of its high abundance. It can consume the phytoplankton and hence compete with the other herbivorous zooplankters, and can also affect the copepods populations by consuming copepod eggs and nauplii. By feeding on marine snow, *N. scintillans* influences processes of remineralization and organic flux. However, quantitative estimates of the role of *N. scintillans* in the zooplankton community of the Black Sea are scarce.

Our study aimed to reveal the contribution of *N. scintillans* to the trophic dynamics of the Black Sea plankton ecosystem. Zooplankton samples were collected on 2 cruises in the northeastern Black Sea in 2009-2010. The content of the *Noctiluca* cells was studied under the dissecting microscope. The proportion of different food types (phytoplankton, copepod eggs and *etc.*) in the daily ration of Noctiluca varied significantly between the cruises.

In addition, in 2010 laboratory experiments were performed to study the digestion time of *N. scintillans* fed on different food types. Digestion times varied from 7 hours for phytoplankton, to 24 hours for *Calanus* eggs. The grazing impact of *N. scintillans* on the primary production in spring can reach 3-5% of primary production, which is comparable to the grazing impact of the dominant copepods. The role of *N. scintillans* in consuming copepod eggs and faecal pellets is also discussed.

March 15, 17:30 (S2-7246)

Population dynamics and predation impact of the introduced ctenophore Mnemiopsis leidyi in the Gullmars fjord, west coast of Sweden

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Lately, waters of northern Europe, including Swedish waters, are facing a new problem with the invasion of the ctenophore *Mnemiopsis leidyi.* Given the rapid growth and high reproductive output of the species, severe effects on its prey populations may be expected. However since the effects on the ecosystem depend on complex interactions in the pelagic community, it is impossible to predict the outcome of the introduction into Swedish waters based on observations from other areas. In the current project we study the development of the *M. leidyi* population in the well documented Gullmars fjord on the west coast of Sweden by sampling the pelagic community for *M.leidyi* and zooplankton approximately once each week. The programme, which also includes, Chl-*a* measurements and CTD casts, has been running from January 2007 and is still ongoing. Results so far has shown a 3 fold increase in the *M. leidyi* biomass from 2007 to 2008/2009 during peak abundances in late summer and the population also remained longer in the water in 2008/2009. Minimum abundances of calanoid copepod prey were observed coincident with peak predation impact in end of August in 2008/2009. This indicates a population regulation effect by *M. leidyi* on copepods. Besides these potential direct predation effects of *M. leidyi*, available data also indicate some indirect effects. Release of phytoplankton from zooplankton grazing-control due to the predation pressure (on zooplankton) from *M.leidyi* resulted in a pronounced phytoplankton bloom - even though the primary production was decreasing during the same period.

W1 Oral Presentations

March 16, 8:35 (W1-7328), Invited

Thinking outside the Z-box: How Individual-Based Models (IBMs) can advance zooplankton ecology

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Modeling is a powerful way to advance zooplankton ecology by testing hypotheses and generating new questions. Traditionally, models represent zooplankton with “Z-box” variables, and describe changes in average values of Z due to physical and/or biological processes. While these models have proven greatly useful, they have limited ability to characterize heterogeneity of size, behavior etc., as well as suffer numerical issues related to maturation times and biological motions. An alternative to Z-boxes are individual-based models (IBMs), which simulate population-level properties that emerge from variations and interactions among individuals. IBMs are particularly amenable to investigations of demographic changes due to complex life histories and environmental dependencies. Moreover, their structure allows for rigorous statistical analyses, accurate simulation of development, and straightforward coupling with circulation.

Here, I showcase novel ways IBMs have been used to address questions about zooplankton ecology that are not easily explored in a Z-box model framework, focusing on studies of environmental influences on copepod population dynamics. IBMs have shown how spatial gradients in the environment lead to variation in individual thermal and feeding histories that affect population size, production and distribution. Examples include demonstration of how different foraging behaviors affect fitness and population growth, and varying phenologies mitigate vulnerability to environmental change. IBMs have also disentangled the relative importance of temperature vs. food effects on recruitment, as well as assess confidence in mortality estimates. Future avenues of research are suggested, including ways IBMs and Z-box models can be used together to improve our understanding and predictive capabilities.

March 16, 9:00 (W1-7240)

Individual Based Model for the phenology of *Eurytemora affinis* from the Seine Estuary, France

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To better understand the population dynamics of the copepod *Eurytemora affinis* from the Seine estuary, we developed a zero-dimensional, temperature dependant, population model. Individual Based Modelling approach was chosen to allow the representation of each life-stage, or group of stages, and consider their differences in temperature development rate and mortality due to predation. Biological functions were selected and calibrated to provide realistic development at temperatures reported in the Seine estuary. The influence of temperature on development times and clutch size were obtained indirectly by fitting stage durations observed in the laboratory at different temperatures and from observations of clutch sizes in the field. The temperature variations were considered using the degree-day approach. Mortality due to predation was parameterized using observed abundances of key predators. The model reproduced the life-history timing (phenology) of the E. *affinis* population observed in the Seine estuary. This IBM also allowed the simulation of the development of the population of E. *affinis* over several years under variable temperature, unlimited food conditions and no density-dependence. Based upon these results, we are reasonably confident that the model captured the role of temperature and predation in driving the seasonal population dynamics of E. *affinis* in the Seine estuary. It hence constitutes a tool, which with the addition of supplemental submodels, might find other applications such as in ecotoxicological studies. This tool could also be used to compare several estuaries (*i.e.*, latitudinal cline) or any natural/anthropogenic scenario. Examples with increasing temperature and shifts in predation pressure are provided.

March 16, 9:20 (W1-7340)

Modelling *Calanus finmarchicus* in the Irminger Sea: From individuals to populations

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The Irminger Sea supports a large proportion of the North Atlantic biomass of the copepod Calanus finmarchicus. Survey data has shown that overwintering individuals are widely distributed at depths exceeding 500m over the entire area Irminger Sea. In the spring these individuals reappear in the surface waters to reproduce. However, the bulk of the recruitment appears to be concentrated along the edges of the Irminger basin along the Irminger current and the East Greenland current. In late summer late-stage copepodites are present once again throughout the basin and are beginning their descent to overwintering depths. From limited historical sampling and Continuous Plankton Recorder (CPR) surveys it seems that this general demographic pattern is persistent. We used a combination of Individual-Based Models (IBMs) and a fully stage-structured discrete-time-and-space Eulerian method in order to understand the interactions between physical transport, spatially and temporally heterogeneous environments, and complex life histories, required to generate this pattern. The biological models were driven by a yearly cycle of temperature and transport from the Ocean Circulation and Climate Advanced Modelling project (OCCAM), and by a food field derived from SeaWiFS satellite sea-surface colour observations and bottle data, and were driven to a quasi-stationary annual in order to compare the results with the survey data. The main factors determining the population dynamics appear to be transport of the population around the Labrador/Irminger Sea gyre, and high mortality rates on early life history stages in the central basin.

March 16, 9:40 (W1-7124)

Using an Individual Based Model with four trophic levels to model fisheries recruitment

Matteo **Sinerchia**[1,2], Wes R. Hinsley[1], Anthony J. Field[1] and John D. Woods[1]

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This paper presents the Lagrangian Ensemble Recruitment Model (LERM), the first prognostic model of fisheries recruitment based upon individuals. It incorporates a classical food chain comprising four functional groups: phytoplankton (diatom), herbivorous zooplankton (calanoid copepod), carnivorous zooplankton (squid paralarvae) and top predators, all modeled as individuals. Their physiology and behavior are described by biological equations taken from the literature and based on reproducible laboratory experiments. LERM is built using the Lagrangian Ensemble metamodel (LEm) in which the demography of the dynamic populations are emergent properties of the virtual ecosystem, resulting from the life-histories of individuals. The paper explores how environmental variability influences the plankton ecosystem and squid recruitment. Simulations are run at an Azores site under stationary annual forcing. After an initial transient period, the ecosystem converges to an attractor. From this stable scenario the sensitivity of the ecosystem to changes in initial conditions and other exogenous factors (predation, spawning and hatching time) are explored. Results suggest that annual recruitment is a complex emergent property dependent on a combination of factors, including food availability, predation, competition, and post-hatching growth rate. Variation in the productive cycle and the timing of spawning are important factors affecting recruitment, as suggested by Cushing's match-mismatch theory. The present model is limited to a 1D ecosystem, but nonetheless represents a key step towards linking small-scale processes governing the life-history of fish larvae and the behavior of fisheries on the large scale.

March 16, 10:30 (W1-7309)

Modeled krill distribution in the California Current from 1990-2005

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Seasonal coastal upwelling is the primary factor controlling peaks in abundance of phytoplankton and some zooplankton species off the West Coast of the United States. Krill species are an important trophic link connecting phytoplankton to many higher trophic level predators in the upwelling system. In years where the timing of peak upwelling has been significantly delayed in the California Current, poor production by krill feeding species (seabirds and salmon) has been observed; this has been hypothesized to have been caused by a mismatch between predator and krill abundance. We present results from a coupled ocean circulation and biological model that explores the spatial and temporal variability in krill abundance and productivity off the Northern California coast in relation to ocean conditions leading up to the time of peak upwelling in the region. Ocean simulations were run for the years 1990 through 2005 using the Regional Ocean Modeling System (ROMS), coupled with a Nutrient-Phytoplankton-Zooplankton-Detritus (NPZD) model. Physical results were used to force a 3-D individual-based model (POPCYCLE) that was parameterized to represent the krill species *Euphausia pacifica*. Results focus on the differences between phases of the Pacific Decadal Oscillation, North Pacific Gyre Oscillation, and on anomalous years in the region when upwelling was significantly delayed. Results indicate that changes in currents, mortality rates, and biological condition all impact the spatial and temporal peaks of *Euphausia pacifica* abundance off Northern California. These model results provide information on the factors that control important prey species productivity in the California Current.

March 16, 10:50 (W1-7307)

North Pacific krill production: A bioenergetic model for *Euphausia pacifica* in the California Current System

Brie **Lindsey** and Harold P. Batchelder

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An individual-based energetic model including growth, mortality, diel-vertical migration and reproduction is developed for *Euphausia pacifica* larvae and adults in the California Current System based on relationships determined from previous literature and more recent laboratory observations. In this model, body growth depends largely on food, while stage progression depends primarily on temperature. A result of the decoupling of growth and development is the ability to express negative growth, a phenomenon commonly observed for euphausiids in the region. Euphausiid reproduction is dependent on body size, temperature and recent food, and is therefore expected to fluctuate with individual location and environmental conditions. The IBM is forced with velocity, food and temperature fields from 3-D ROMS simulations to examine the impacts of various conditions on *E. pacifica* egg production in the Oregon upwelling region. The model is evaluated using GLOBEC cruise data. Estimates of relative egg abundances are compared with abundance patterns observed in the area.

March 16, 11:10 (W1-7288)

Comparison of IBM and concentration based approaches to modeling krill growth and population dynamics

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There is uncertainty about the appropriate modeling approach for including motile organisms in marine ecosystem models. Individual-based models (IBMs) offer tremendous flexibility in the implementation of diverse stage- or weight-dependent rate processes such as prey preference, vertical migratory behaviors, active horizontal movement, and metabolic and mortality rates. Thus, IBMs have been used extensively to examine growth of larval fish, meroplanktonic stages of benthic species and some larger holozooplankton. However, in IBMs it is difficult to simulate realistic densities, or to consider the feedbacks (prey depletion; nutrient regeneration) to the underlying Eulerian ecosystem model that provide the prey fields. These limitations become important when examining quantitative responses of ecosystems to potential future climate scenarios, as changes in the relative contribution of larger plankton and feedback processes may be important responses in such scenarios.

We compare the growth and population dynamics of the euphausiid *Euphausia pacifica* in an IBM to the growth and population dynamics resulting from a simplified stage-structured Eulerian (concentration based) ecosystem model that includes krill. For both approaches, the North Pacific Ecosystem Model for Understanding Regional Oceanography (NEMURO) model is used to simulate the dynamics of the lower trophic level state variables. For the concentration model, we add five aggregated life-stages of krill to NEMURO. The life stages are distinguished by feeding on different prey types and having different diel vertical migration behaviors. Results of this comparison will identify promising approaches for examining ecosystem responses to hypothesized future scenarios of physical forcing, as might occur with climate change.

W2 Oral Presentations

March 16, 8:35 (W2-7120), Invited

Rapid evolution during independent copepod invasions into novel environments

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A fundamental unresolved problem in ecology and evolution regards limits to species distributions. Invasive species provide powerful models for studying limits to species distributions and factors that allow those distributions to shift. Within the past century, the copepod *Eurytemora affinis* has invaded freshwater habitats multiple times independently from saline sources. To dissect evolutionary responses during these independent habitat invasions, we integrated analyses of physiological function with comparative functional genomics. We analyzed evolutionary shifts during invasions for pairs of ancestral saline source and derived freshwater populations across four independent invasions from two genetically distinct clades. We found evolutionary shifts in function (ion efflux, ion uptake), as well as in expression of genes spanning many functional categories, including osmoregulation, energy production, and stress response (based on custom microarrays). In many cases, there were striking parallel evolutionary shifts across independent invasions, particularly with respect to ion uptake activity and expression. Several of the candidate genes appear to show significant signatures of selection based on summary statistics. We are developing a demography + selection model of invasions in order to rigorously test for signatures of selection at our candidate loci. The evolutionary parallelism observed here might have relevance for taxonomically different but ecologically similar species that invade across similar habitat clines.

March 16, 9:00 (W2-7105)

Microarray studies in a calanoid copepod, *Calanus finmarchicus*

Petra H. **Lenz**[1,4], R. Patrick Hassett[2], Paola Batta Lona[3], Ebru Unal[3], Benjamin King[4], Ann Bucklin[3] and David W. Towle[4]

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We are exploring the application of genomic tools to investigate environment-organism interactions in calanoid copepods. At this workshop we will discuss our preliminary work on gene expression patterns in *Calanus finmarchicus* using a species-specific microarray with 1000 cDNA. The probes represented in the microarray include genes involved in growth and reproduction, respiration, digestion, lipid metabolism, cellular processes, stress response and biological rhythms. Microarray comparisons were made between pre-adult (C5) morphotypes (lipid-rich vs. lipid-poor) collected from the Gulf of Maine during the summer, and between adult females kept at high or low food conditions for a period of one week. Microarray results indicated that the lipid-rich C5 showed up-regulation for several probes that coded for proteins involved in cell growth and hormonal regulation. Comparisons between experimental groups indicated consistent patterns in up- and down-regulated genes. Overall, observed differences in gene expression were moderate, and typically less than 4-fold different. In these preliminary studies, we have started to identify a subset of genes that appear to be regulated in the copepods collected from the field as well as those maintained under different experimental conditions.

March 16, 9:15 (W2-7066)

Gene expression analysis of time-series collections of *Calanus finmarchicus* in the Gulf of Maine, NW Atlantic Ocean

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DNA microarray technology allows rapid characterization of genome-wide patterns of gene expression, and may be used to discover metabolic genes involved in physiological adaptation and environmental response. In this study, expressed sequence tag (EST) microarray analysis was used to investigate gene expression profiles of field-collected specimens of the planktonic calanoid copepod, *Calanus finmarchicus*, in the Gulf of Maine between March 2005 and April 2008. *Calanus* physiology microarrays were printed using 1,000 EST probes designed from selected genes of known function, including environmental stress, metabolism, molting, digestion, neural processes, and membrane physiology. The hybridization results of nine microarray experiments revealed marked differential up- or down-regulation (*i.e.*, more than 1.0 log ratio) for >70 genes in comparisons between samples collected at different times of year and from different depth zones. Groups of high-responder genes that may control critical physiological life history processes have been identified through principle component analysis and multiple group comparisons. Target genes of known function and possible significance for physiological adaptation were identified, and their expression levels will be confirmed by quantitative PCR.

March 16, 9:30 (W2-6942)

A comparison of the mitochondrial genomes of five species of North Pacific krill

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Euphausiids form a key link in the north Pacific between primary producers and upper trophic levels, including marine fishes, birds, and mammals. In spite of their central role in the north Pacific ecosystem, little is known about the genetics of these important organisms. This knowledge could greatly increase our understanding of population structure, species relationships, and how individual species may respond under the influence of climate change. Mitochondrial DNA (mtDNA) evolves rapidly, is maternally inherited, and does not undergo recombination. Therefore, it is particularly useful for studies of gene flow within species, and for studies of the evolutionary relationships between organisms. We have begun to sequence the complete mitochondrial genomes of five species of north Pacific krill: *Thysanoessa raschii*, *T. inermis*, *T. spinifera*, *T. longipes*, and *Euphausia pacifica*. The goals of the project are to identify potential molecular markers for population genetic study, and to investigate the phylogenetic relationships within the Euphausiacea. We are using a long-range PCR approach with primers designed for *Euphausia superba* to produce template DNA that will be sequenced on the Roche/454 GS Junior next-generation sequencer. Two individuals per species will be sequenced for all species with the exception of *T. raschii*, which will be represented by two samples from the north Pacific and two from the north Atlantic, representing the extremes of its natural range. Sequence data will be assembled using the *E. superba* mitogenome as a template, and phylogenetic relationships estimated using neighbor-joining and Bayesian analyses.

March 16, 9:45 (W2-7160)

Do we know the known? Zooplankton biodiversity of the North Sea

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In times of new and faster methods for species identification and diversity acquisition, species-rich habitats, such as tropical coral reefs or deep-sea ecosystems, are highly attractive for large-scale biodiversity assessments based on molecular identification methods. In contrast, habitats with a well-documented metazoan fauna, e.g. the temperate North Sea, are neglected. However, these habitats in particular show first indications of climate change and, as a consequence, dramatic changes in the diversity of communities. We aim to characterize the molecular genetic diversity of the North Sea metazoan fauna by applying a DNA barcoding approach on the basis of mitochondrial COI as well as alternative nuclear markers. Based on this sequence database, the diversity of zooplankton communities will be assessed by metagenetic analysis with special emphasis on meroplankton larvae, which are otherwise difficult to identify to the species level based on morphological characters. This approach seeks to reinforce long-term North Sea zooplankton time series in order to detect patterns and processes of changes in secondary production. Furthermore, this work focuses on the genetic variability of widely distributed neritic calanoid copepod species that are highly abundant and thus key players in the North Sea ecosystem. Preliminary results of this recently started campaign will be presented.

March 16, 10:30 (W2-6960)

Molecular identification of zooplankton: 10 years on

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A persistent problem when investigating marine zooplankton communities is the correct identification of species present. Zooplankton are systematically diverse and present considerable taxonomic challenges. In particular, copepods are morphologically similar and identification to species level at early developmental stages presents an incessant problem to zooplankton ecologists. However, unambiguous species identification is essential to obtain an accurate description of zooplankton diversity, distribution and demography and, to assess how changing climatic conditions affect biogeographical range or shifts in community composition.

A decade ago Lindeque and others began to utilise DNA sequences of homologous gene regions to design molecular techniques, such as RFLP and multiplexed species-specific PCR, to discriminate between closely related North Atlantic *Calanus* species. Identification techniques have now been developed for other genera such as *Pseudocalanus* and *Clausocalanus* and the number of DNA sequences for copepods, available through genetic databases, has grown considerably, not least through the efforts of CMarZ. These Barcoding genes are predominantly mitochondrial genetic markers such as 16S rRNA and COI genes. Molecular identification techniques have increased species resolution, allowed a more accurate description of geographical distribution, been merged with microscopy for large-scale field surveys and helped answer ecological questions. However, they are still limited to specific genera and are not suitable for composition assessment of bulk zooplankton samples.

Has the time now come to progress molecular identification of zooplankton to 'ecological genomics' or next generation sequencing? Can we successfully adapt the metagenomic approach used for prokaryotic assemblages to metazoans? The pros, cons and pitfalls will be discussed.

March 16, 10:45 (W2-6909)

Genetic evidence of distinct new *Collinia* species, parasitoids of krill from the Bering Sea to the Baja California peninsula region

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To explore the ecological function and host specificity of krill parasitoids, we used molecular methods to identify three *Collinia* species, ciliates that kill the seven most abundant and trophically relevant krill species in the Northeastern Pacific Ocean (23–55°N), occasionally causing massive epizootic events. Genetic evidence showed host specificity: *Collinia beringensis* infects *Thysanoessa inermis, Thysanoessa raschii*, and *Thysanoessa longipes* in the Bering Sea; *Collinia oregonensis* infects *Euphausia pacifica*, *Thysanoessa spinifera,* and *Thysanoessa gregaria* along the Oregon and California coasts; and an as-yet undescribed species of *Collinia* infects the sac-spawning *Nyctiphanes simplex* along the west coast of Baja California and in the Gulf of California. The new *Collinia* species revealed two novel features of the *Collinia* life-cycle: (1) all life stages are associated with opportunistic bacterial assemblages that can end in bacteremia; and (2) the encysted cells or phoronts form dense ciliate-bacterial mucilage filaments, probably mixed with marine snow, that apparently infect krill when they are ingested. This latter conclusion is based on 16S rRNA gene sequences from bacterial assemblages derived from *Collinia* at each life stage, from bacterial communities from the stomachs of healthy krill, and from the hemocoel of infected krill. Our genetic evidence also suggests that the *Collinia*-krill parasitoidism has co-evolved as an interaction independent of the host reproductive strategy (i.e., broadcast or sac-spawning). We predict that parasitoid-krill interactions occur in other krill species of the Order Euphausiacea, with yet undefined effects on mortality rates and population dynamics.

March 16, 11:00 (W2-6965)

Calanus spp. feeding rates on a diatom species estimated by quantitative PCR

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To accurately estimate copepod *in situ* feeding rates we have recently developed a quantitative PCR (qPCR) based assay using prey-specific 18S rDNA genes as target molecules. Although this method offers several benefits compared to classical approaches (*e.g.* microscopic or pigment analysis of gut content), we have repeatedly demonstrated in laboratory experiments that the qPCR-derived copepod gut content estimates suffer from underestimation due to rapid digestion of the prey DNA. However, when applied to copepods feeding under more natural conditions, realistic feeding rates were obtained. The reason for this difference is still unknown, however our results indicate that copepods sampled *in situ* may not suffer from substantial prey DNA digestion, and therefore the qPCR approach described here can be used to estimate their feeding rates on single prey species. In this study we estimated by qPCR the number of diatoms (*Skeletonema marinoi*) in guts of the *Calanus* spp. collected from a mesocosm study and from a fjord system. The derived feeding rates corresponded to those obtained from simultaneous bottle incubation experiments and from literature data.

March 16, 11:15 (W2-7217)

DNA analysis of prey in zooplankton: From gut contents to feeding rates

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DNA analysis of zooplankton gut contents provides a way of unambiguously identifying different prey species ingested *in situ*. Here we present two aspects of our recent efforts to develop and utilize DNA-based methods to understand the feeding ecology of marine zooplankton. First, we have developed a DNA-PNA method to quantitatively determine zooplankton ingestion rates. We have been measuring DNA digestion rates using this method and will describe the effects of food concentration on gut contents and rates of gut filling using quantitative PCR. Second, we show that the method can also be used to determine the *in-situ* prey spectrum using the northern krill *Meganyctiphanes norvegica* in the Gulf of Maine. We were able to identify a suite of prey items and then quantify the most common prey items in individual krill guts. An unknown benthic microeukaryote was identified that comprised approximately half of krill diets in the Gulf of Maine, revealing a new pathway for carbon flow from the sediments to the pelagic. Over 100,000 tons of carbon may be brought back into the Gulf of Maine pelagic ecosystem annually by krill benthic feeding, more than that required by the region's entire fin whale population.

March 16, 11:30 (W2-7065)

Zooplankton populations isolated in marine lakes: Natural laboratories of evolution?

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Little is known about how pelagic (open ocean) biodiversity is created and maintained. Understanding evolutionary processes in the open sea is particularly difficult because barriers to migration are often obscure and fossil records are typically lacking. We have studied populations of the copepod *Calanus helgolandicus* and the chaetognath *Sagitta setosa* isolated in marine lakes in Ireland and Croatia. Marine lakes provide extraordinary opportunities to study evolution of zooplankton because populations have invaded these lakes by known flooding events (during the Holocene) from ancestral populations in the adjacent sea. Preliminary results (based on mitochondrial gene sequences) suggest that zooplankton populations in the Irish lakes are not significantly isolated from the adjacent sea, whereas populations in Croatian lakes are strongly differentiated. Furthermore, we found strong evidence of fast adaptive evolution of *S. setosa* populations isolated in the Croatian lakes based on morphometric (17 measurements), nuclear DNA (four microsatellites), and mitochondrial DNA (two genes) data. These findings force a careful re-evaluation of the tempo and mode of marine zooplankton evolution.

March 16, 11:45 (W2-6950)

Genetic diversity of pelagic chaetognaths

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Chaetognaths are one of the dominant groups of carnivorous zooplankton in terms of abundance, biomass, and ubiquity. We reexamined the traditional morphological taxonomy of chaetognaths by molecular genetic analyses using mitochondrial COI gene sequences. As a result, distinct genetic differentiation was found within many morphological species. Based on genetic distances alone, the cryptic species that were newly recognized would double the number of species, indicating that current morphological taxonomy has seriously underestimated the species diversity of chaetognaths. In some cryptic species, morphological characters that are useful for species identification also have been found. We further examined the geographical distribution of cryptic species within the deep-sea chaetognath *Eukrohnia hamata*. On the basis of specimens from the global ocean, we recognized four lineages (Ham-A to D) that show genetic distances comparable to those between morphological species of chaetognaths. Ham-B and C were cosmopolitan groups, while Ham-A and D were limited to the Antarctic and North Pacific Oceans, respectively. Demographic analysis showed that Ham-A and D have experienced bottleneck events and population expansion during the Quaternary glaciations. Ham-B and C comprised five and four sub-populations, respectively. Within some sub-populations, the individuals collected from the Atlantic and the equatorial Pacific shared the same haplotypes, suggesting that gene flow is possible over several thousand kilometers. However, differentiation often appears to have occurred between adjacent waters, suggesting that speciation also has taken place in the absence of apparent physical barriers.

March 16, 12:00 (W2-7213)

Does habitat specialization drive population genetic structure of oceanic zooplankton?

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Marine zooplankton were long thought to be ‘high gene–flow’ systems with little genetic differentiation among populations, due to large census population sizes and an absence of observable barriers in the open sea. Early genetic studies of oceanic species generally supported this expectation, with observations of high gene flow across 1000s of km of oceanic habitat. A number of recent studies have challenged this view by demonstrating significant genetic structure across a range of spatial scales, and by showing that dispersal capacity may be moderated by species–specific ecological traits. Which ecological traits are primary determinants of dispersal among populations of open ocean species? I will provide an overview of our ongoing research to test the hypothesis that habitat depth specialization is a primary trait driving large–scale population genetic structure of open ocean plankton. This comparative study targets eight species of planktonic copepods that utilize strikingly different depth–related habitats in order to test key predictions about how organismal depth interacts with oceanography and bathymetry to control genetic structure. Early results confirm that zooplanktonic organisms can be genetically subdivided throughout their global range, and seem to suggest greater population subdivision for deeper–dwelling taxa. In particular, results for *Pleuromamma xiphias*, a deep vertical migrator, demonstrate unexpectedly high levels of genetic differentiation between populations both within and across the Indian, Pacific, and Atlantic Oceans. Finally, I will discuss future research directions in this sub-discipline, and strategies for novel nuclear marker development.

W3 Oral Presentations

March 16, 8:35 (W3-7116), Invited

Zooplankton time series from eastern boundary upwelling ecosystems: Within- and between-system comparisons

Jenny **Huggett**[1,2], Todd D. O'Brien[3], Hans Verheye[1,2], Ángel López-Urrutia[4], Patricia Ayón[5], Rubén Escribano[6], Larry Hutchings[1,2], Anja Kreiner[7], David L. Mackas[8], Mark D. Ohman[9], William T. Peterson[10] and Chris Reason[11,2]

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Zooplankton are useful indicators of climate change as they have short life spans and respond relatively quickly to changes in ocean conditions. Upwelling ecosystems are challenging yet enlightening open-ocean laboratories, as they are characterized by high temporal and spatial variability in the short-term (days to years), as well as by long-term (decadal) fluctuations in species composition within the pelagic realm. Long-term monitoring and analysis of zooplankton biomass and species composition are most advanced in the California Current, where the CalCOFI sampling programme began in 1949. A long-term decline in zooplankton biovolume in this area has been attributed to a decline in pelagic tunicates, and not in copepod or euphausiid taxa which routinely dominate the biomass (Lavaniegos and Ohman 2007). This highlights the importance of exploring changes in species composition in addition to changes in bulk biomass or total abundance.

To date there are roughly a dozen zooplankton monitoring programmes within eastern boundary upwelling ecosystems, ranging from single to multiple transects across the continental shelf. This presentation will provide an update on zooplankton time series from the Benguela, California, Canary (Iberian Peninsula) and Humboldt Current upwelling ecosystems. Our focus will be on within- and between-system comparisons, thereby exploring possible relationships with local and global climate forcing. We also aim to delve deeper into shifts in species composition and abundance of key species or species groups, which we hope may provide greater insight into the impacts of changing ocean conditions on zooplankton communities.

March 16, 9:00 (W3-7075)

Long term changes in zooplankton size distribution in the Peruvian Humboldt Current System: Conditions favouring sardine or anchovy

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Changes in the size distribution of zooplankton in the Humboldt Current System have been hypothesized to underlie observed changes in sardine and anchovy populations, the dominant pelagic fish species. To examine this hypothesis, the size distribution of over 15,000 zooplankton data samples, collected since the 1960s, was qualitatively determined. Dominance of each size group of zooplankton (small, medium and large) and of euphausiids was modelled using Generalized Additive Models as a function of year, latitude, time of day, distance from the 200-m isobath (a surrogate for on shelf *vs.* off shelf), sea surface temperature and salinity. The temporal (year) pattern for euphausiid dominance was highly cross-correlated (*i.e.* was in phase) with the time series for estimated biomass of anchovy, and small zooplankton dominance with that for estimated sardine biomass. This supports a mechanism based on feeding-energetic experiments, which showed energetic advantages to sardine filter feeding on smaller zooplankton and to anchovy bite feeding on larger copepods and euphausiids.

Although euphausiids predominate offshore of the shelf break, anchovy biomass is generally highest on the shelf, suggesting a possible mismatch between anchovy feeding and euphausiid dominance. However, evidence concerning the offshore expansion of the anchovy range in cooler conditions, in which both anchovy and euphausiids predominate, somewhat alleviates this apparent contradiction. A strong diel component to euphausiids and large zooplankton indicated diel migration for these zooplankton groups. That anchovy will preferentially eat euphausiids when they are more available (*i.e.* during the night and offshore) is supported by anchovy diet data.

March 16, 9:15 (W3-7230)

The COPEPOD Interactive Time-series Explorer (COPEPODITE)

Todd D. **O'Brien**

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The Coastal & Oceanic Plankton Ecology, Production & Observation Database (COPEPOD) has been working with plankton time series data for over seven years. Providing data processing and analysis support to working groups such as the ICES Working Group on Zooplankton Ecology (WGZE) and the SCOR Global Comparisons of Zooplankton Time Series (WG125), COPEPOD has developed an impressive in-house collection of plankton time series visualization tools and analyses. Investigators can now apply these tools and visualizations to their own data using the online COPEPOD Interactive Time-series Explorer (COPEPODITE).

COPEPODITE allows the investigator to visualize their data using a variety of graphical and processing options, all selected through the online menu system. The most basic option provides a statistical and graphical overview of the data, useful in highlighting trends and/or anomalous data points. Another option generates a seasonal overview of temperature, chlorophyll, wind, and day light patterns (specific to the investigator's sampling site) using relevant data from global satellite and *in situ* data products. For plankton time series with species data, additional options allow the investigator to cluster, visualize, and compare these data via investigator-specified groupings. Finally, a variety of correlation options can compare the data to *in situ* hydrographic data as well as localized long-term temperature records and/or locally relevant climate indices (*i.e.*, the NAO for North Atlantic sites, the PDO for North Pacific sites).

March 16, 9:30 (W3-7095)

Zooplankton trends in an oligotrophic open area of the Balearic Sea (central western Mediterranean)

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The Balearic Sea, located in the central western Mediterranean, is characterized by a mixing of water masses from the cooler, saline waters of the northwest Mediterranean with warmer, less saline waters of Atlantic origin. We present an analysis of fifteen years (1994-2008) of hydrographic and zooplankton abundance data sampled at a Balearic Sea monitoring station located southwest of Mallorca island.

Seasonal and interannual cycles were present in all of the identified zooplankton groups, with interannual patterns most clearly visible in the copepods, appendicularians, and cladocerans. Water temperatures exhibited strong seasonal patterns but weaker interannual patterns, while salinity exhibited weak seasonal patterns but stronger interannual patterns (the latter reflecting variability in the relative compositions in the two Balearic Sea water masses). Strong positive (or negative) relationships were evident between the hydrography and many of the zooplankton groups, highlighting the composition of the Balearic Sea water masses as a major driver of biological variability in this region.

Monitoring site water temperatures and salinities revealed a slight increasing trend over the sampling period, corresponding to larger-scale and longer term changes occurring in the larger western Mediterranean basin. Measured as a whole (*i.e.*, total zooplankton abundance or total sample biomass) the mesozooplankton did not show consistent trends over this same sampling period. Looking at individual groups (*e.g.,* copepods and gelatinous zooplankton), some trends were evident. These indicate changes in the relative composition of the mesozooplankton community in response to both short term and longer term changes in the Balearic Sea water masses.

March 16, 9:45 (W3-6886)

Understanding populations changes in time due to niche requirements

Pierre **Helaouet**[1], Martin Edwards[1] and Grégory Beaugrand[2]

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The ability to monitor both seasonal timing and abundance of targeted species offers the possibility of quantifying population changes due to the changing climate and therefore the associated ecosystem evolution. Here we use a new method to quantify through time the suitability of a given habitat for a given species. Directly based on the theory that the ecological niche represents the requirements of a species regarding its environment, the method calculates a seasonal standardised index of habitat suitability. This index is derived from a two-dimensional representation of the ecological niche of a species, closely matches its abundance, and thus offers a new tool to assess the abundance of targeted species at different time and space scales. Both the structure and functioning of pelagic mid and high-latitude ecosystems are influenced by the dynamics of copepod populations which are responsible for much of the energy transfer from the primary producers to higher trophic levels. The method, being focus on the environmental requirements of a species, provides a new tool to disentangle direct anthropogenic effects such as fishing or habitat fragmentation on a species from natural climate oscillations and variability.As a case study, I apply this method to Continuous Plankton Recorder time series of both *Calanus finmarchicus* and *C. helgolandicus* in the North Sea to examine the changing dynamics of that ecosystem. It has been suggested that *Calanus finmarchicus* is representative of the Atlantic Arctic biome (cold oceanic environment). Therefore, a decline in its abundance in the North Sea in favour of its congeneric species *(i.e. C. helgolandicus* adapted to more temperate water masses) may indicate that the subarctic biome has moved northward, potentially having deep repercussions on the food web.

March 16, 10:30 (W3-7199)

Comparative time series analyses in the English Channel

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Plymouth Marine Laboratory (UK) and IFREMER Boulogne (France) have established time series of zooplankton species in the western and eastern English Channel since 1988 and 1975, resectively. At L4, a coastal station off Plymouth, each taxonomic category is described by its variations in abundance, the annual average, and variations in seasonality. Parameters additionally measured on a weekly basis include phytoplankton species composition and biomass since 1992 as well as nutrient information since 2000. Copepod egg production data, particularly of *Calanus helgolandicus*, are also available for several years as well as experimental results on this copepod's diet and reproduction as well as physical and chemical parameters, including vertical temperature and salinity profiles.

At Gravelines, a coastal Station on the French coast of the Dover straits a research programme (designed to monitor the effects of nuclear power plants on the environment and living resources) includes the following parameters measured on a weekly basis: temperature and salinity, ammonium, nitrate, chlorophyll *a* and phaeopigment concentrations, as well as phytoplankton abundance.

By integrating these *in situ* measurements at both sides of the Channel, we can quantify phenologies and their dependence on environmental factors. These observations will help elucidate changes in the planktonic food web and higher trophic levels. Through collaborations along the British and French coasts, we hope to develop a multidisciplinary ecosystem-based approach that will encompass the whole English Channel. Such analyses provide a resource to develop a comprehensive plankton inventory of the English Channel with scope for the development of multimetric food web indices.

March 16, 10:45 (W3-7284)

Interannual variability in abundance and seasonal timing of dominant species, immigrant groups, and functional groups at six stations in the northwest Atlantic

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The Atlantic Zone Monitoring Program (AZMP) has collected zooplankton and environmental data at monthly or semi-monthly frequencies at six stations in the northwest Atlantic since 1999. Stations are located on the Newfoundland Shelf, in the northwest and western Gulf of Saint Lawrence, on the Scotian Shelf, and in the Bay of Fundy. Circulation in the northwest Atlantic continental shelf system is dominated by mean equatorward flow, influenced by the inshore and offshore branches of the Labrador Current. Strong advection along the shelf is reflected in broad distributions of many zooplankton species abundant throughout the zone. However, several dominant shelf species are at the edge of their ranges. The contributions of nearshore and offshore communities vary at the different stations. The research presented here compares interannual variability patterns in the abundance and seasonal timing of dominant species, immigrant groups, and functional groups at the six stations, and evaluates the relationships between zooplankton and environmental variability at each station. Preliminary analysis suggests that coherent patterns of interannual variability in species and group abundance are most common at adjacent stations, while coherence in abundance variability across the entire zone is more difficult to discern. The abundance of small, shelf-associated copepod species appears to co-vary at most of the stations, similar to patterns observed in the Gulf of Maine, suggesting that small copepods are responding similarly to environmental variability occurring at regional scales. The long-term objective is to better understand how zooplankton communities might change in light of anticipated trends in environmental conditions.

March 16, 11:00 (W3-7228)

Recent changes of meso-zooplankton community in the western North Pacific Ocean

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Our research group had studied the decadal-scale variation in meso-zooplankton community by using the long-term zooplankton sample set of "Odate Collection" from 1960 to 2000. We are continuing the monitoring in the western North Pacific Ocean after 2000. In this study, we will describe recent changes of the meso-zooplankton community by using both sets of samples. *Neocalanus cristatus* and *N. flemingeri* had high biomass during 2000s in the Oyashio waters. In the previous study, we revealed that the copepods had significant increasing trend in biomass from 1960s to 2000. We confirm in this study that the increasing trend continued after 2000. These copepods are spring species. The upward trend of copepod biomass might be related to variation in primary production: the spring primary production also had an increasing trend, perhaps caused by increased light availability in relation to global warming. *N. plumchrus* (which is a summer species) also had high biomass from early to late 2000s. We will also discuss the effects of environmental factors to the variation in the biomass.

March 16, 11:15 (W3-7140)

15 years of biweekly sampling along the Newport Hydrographic Line: An update

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The Peterson lab has been sampling hydrography and zooplankton in the coastal northern California Current, along the Newport Hydrographic Line (44°40'N, 124°W) since 1996. This observational program includes sampling along a 40 km long transect at stations across the shelf and slope, every two weeks, year around. Variables measured include water column profiles of temperature, salinity, fluorescence, and oxygen along with Secchi depths, surface bucket samples for chlorophyll and nutrients, and plankton net tows for zooplankton, ichthyoplankton and euphausiids. By the end of 2010, 400 visits to this line had been completed. This extensive data set allows study of relationships between basin-scale and local-scale climate forcing on hydrography and zooplankton at a range of cascading temporal scales, from upwelling events to interannual. When coupled with about 10 years of historical data collected in the 1970s, 1980s and early 1990s, decadal variability can be investigated. Strong associations between sign of the PDO and copepod community structure are observed – years with negative PDO are characterized by a cold water neritic community and positive PDO by warm water subtropical neritic/oceanic community. This suggests that large-scale transport processes control species composition in the coastal upwelling zone off Oregon, whereas upwelling itself may control only local productivity. Increased biodiversity (measured as copepod species richness) and a general (albeit slight) warming is also observed suggesting that the northern California Current is slowly becoming more subtropical in nature.

March 16, 11:30 (W3-7080)

Flow-field fluctuations *vs.* warming trend: What is driving meridional shifts in zooplankton distribution ranges and community dominance?

David L. **Mackas**

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There are now many examples of meridional displacements of the distribution ranges of both zooplankton and fish. Within local time series, these express themselves as changes in community composition, and replacements of higher latitude by lower latitude species. Larger scale time series (such as CPR) and among-region comparisons of local time series are able to establish short- and long-term rates of spatial displacement. At interannual to decadal time scales, both views of zoogeographic distribution shifts show synchrony with the fluctuations of climate indices such as ENSO, PDO and NAO, and are almost certainly driven in part by associated and transient anomalies in the speed and direction of winds and currents. But the time series also often include (and are sometimes dominated by) underlying and progressive poleward trends. Are trends present because the advective/migratory component of population change has a built-in directional ratchet? Or because the zones of 'optimal habitat' as determined by scalar environmental variables are being moved poleward by global warming? Or both? Unfortunately, I'm not yet sure about the answer, but I can and will show you some interesting examples, and will also discuss implications for detection and prediction of future changes.

W4 Oral Presentations

March 16, 8:35 (W4-7106), Invited

Zooplankton physiology in a changing ocean: Synergistic effects of climate-related variables on metabolism

Brad A. **Seibel**

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Unlike air-breathing animals, aquatic organisms generally maintain extracellular CO_2-concentrations in equilibrium with the respired medium. Thus, as seawater PCO_2 increases, the PCO_2 of extra-, and to a lesser extent, intracellular fluids in zooplankton increases. High internal PCO_2 may affect numerous processes, but a common response is the suppression of total energy consumption (*i.e.* metabolic suppression). The extent to which elevated PCO_2 affects zooplankton physiology depends, in part, on their capacity to buffer pH changes and transport proton-equivalent ions out of the cell and most species show no detectable effect on metabolism of the small increases in CO_2 expected under climate-change scenarios. However, CO_2 is not changing in isolation and animal metabolism is strongly dependent on a variety of environmental variables and on the animal's own nutritional state. Climate change alters temperature and oxygen levels as well as CO_2 and may influence feeding dynamics via effects on primary productivity and ecological interactions with less tolerant species. Here I present examples of potentially important metabolic effects of ocean acidification that are only detectable in combination with specific temperatures and oxygen levels or that are masked or ameliorated by feeding history.

March 16, 9:00 (W4-6895)

Microzooplankton feeding and growth in an acidified ocean

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Despite recognition as key members of marine food webs, microzooplankton are largely absent from the growing number of studies exploring the effects of ocean acidification on marine zooplankton. Sensitivity by microzooplankton to ocean acidification may potentially alter many important marine biogeochemical cycles, namely C, N and P transfer and regeneration. Ocean acidification may affect microzooplankton directly, or indirectly through ingestion of prey whose own biochemistry or physiology is altered by ocean acidification. To study ocean acidification effects on microzooplankton feeding ecology we developed a novel laboratory experimental system that allows air-sea gas exchange to drive our carbonate chemistry, rather than direct bubbling of CO_2 enriched air into media. Our model organisms are several species of microzooplankton, including dinoflagellates and ciliates, and calcifying (CCMP 2668) and non-calcifying (CCMP 373) strains of *Emiliania huxleyi*. Both microzooplankton and *E. huxleyi* cultures are grown in air-tight boxes supplied with either ambient, 750 or 1000 ppm CO_2-enriched air. When individual microzooplankton species are acclimated to CO_2-enriched conditions, ingestion and growth rates across CO_2 treatments are the same as ambient controls when feeding on non-acclimated prey, suggesting that they are not directly affected by acidified conditions. We have shown that both strains of *E. huxleyi* alter aspects of their physiology and biochemistry when grown under acidified conditions. Experiments are currently underway to determine whether these changes in prey state affect the feeding or growth rate of microzooplankton grazers. We will discuss the results and implications of these experiments, as well as describe our experimental system.

March 16, 9:20 (W4-7280)

The response of zooplankton to elevated CO_2 concentrations: Results from a mesocosm experiment in a high Arctic fjord

Barbara **Niehoff**[1], Jan Czerny[2], Signe Klavsen[2], Sebastian Krug[2] and Kai Schulz[2]

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Zooplankton are a key component in pelagic marine ecosystems, linking primary production to higher trophic levels. Knowledge about their response to elevated CO_2 concentration is essential for understanding and modelling ecosystem processes related to climate change. We therefore focused on the development changes of zooplankton abundance and species composition during a five-week mesocosm experiment conducted in the Kongsfjord on Svalbard in June/July 2010. Nine mesocoms of approx. 15m in length and 3m in diameter were deployed. The seawater enclosed in the mesocosms was enriched with CO_2, resulting in concentrations of 2*180 (control), 256, 354, 457, 658, 780, 1005 and 1354 ppm. After two weeks, nutrients were added to initiate a phytoplankton bloom. Temperature and chlorophyll *a* content were monitored on a daily basis in the mesocoms and the fjord. Zooplankton samples were taken weekly by hand with an Apstein net (55µm) from 12 m depth to the surface and preserved in formalin buffered with borax. Over the entire experiment, meorplanktonic larvae dominated the zooplankton community of all nine mesocosms. Cirripedia larvae were most abundant, followed by bivalve and polychaete larvae. *Calanus* spp. was relatively scarce. *C. glacialis* was mainly in copepodite stage III, while the few *C. finmarchicus* specimens found were either in stage V or adult females; *C. hyperboreus* was found only on few occasions.

March 16, 9:40 (W4-7036)

Does the allelopathic and toxic activity of *Alexandrium minutum* change with ocean acidification?

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Species within the toxic genus *Alexandrium* produce a number of bioactive compounds that are responsible for deleterious effects and competitive advantages in marine food webs. The disruption of metazoan zooplankton grazing by feeding deterrence or toxicity has been attributed to a defensive role of phycotoxins, whereas the allelopathic activity against competing algae is caused by some unknown lytic compounds. We will present results of an investigation on how this allelopathic, feeding deterrent and toxic activity is modified in response to the alteration of the [CO_2]/pH. Several strains of *Alexandrium minutum* were grown in turbidostats at a different seawater pH levels ranging from 7.7 to 8.6 and, thus, covering current levels to predicted future scenarios. In 6-days laboratory experiments, we compared the feeding activity, egg production, egg hatching success and faeces production of the copepod *Acartia tonsa* at a fixed food concentration. Additionally, toxicity and allelopathic activity of the A. *minutum* strains against *Rhodomonas* sp. was monitored. The results of these experiments show that the feeding deterrent and allelopathic activity of *Alexandrium* as well as the reproductive success of *A. tonsa* depend strongly on algal growth conditions. In addition, the feeding deterrent activity of *A. minutum* did neither correlate with the observed changes in the phycotoxin content nor with changes in the allelopathic activity. We will discuss the results with regard to our present understanding of the control of *Alexandrium*-copepod interactions and of its potential modification associated with climate change.

March 16, 10:30 (W4-7329)

Effects of ocean warming and acidification on larval development in the diadematoid sea urchin *Centrostephanus rodgersii*

Maria Byrne[1], Steve **Doo**[1,2], Natalie Soars[1] and Symon Sworjanyn[3]

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Effects of ocean warming and acidification have been documented across many taxa but interactive effects of these two stressors have not been well studied. *Centrostephanus rodgersii*, the spiny/black sea urchin, is an important keystone species located in temperate waters along the eastern coast of Australia and can cause wide scale barrens affecting industries such as fisheries. Detailed efforts to characterize effects of climate change on each life stage are crucial to understanding how this species will respond to future predicted scenarios. *C. rodgersii* larvae were reared from fertilization to 5-days in three predicted future ocean pH conditions (7.6, 7.8, and 8.2) and two temperature conditions (22°C ambient control, 24°C) in a flow through sea water system. The length of the two postoral arms was measured. Total arm length was used as a proxy for larval calcification. Initial results indicate that at control temperature, ocean acidification conditions resulted in a significant decrease in larval size with smaller arms in larvae from pH 7.6-7.8 treatments. At elevated temperatures, trends are less apparent. Further analyses of effects on other life stages will provide insight into calcification response of *C. rodgersii* in predicted elevated pCO_2 and temperature conditions and will aid in characterization of possible ecosystem regime shifts.

March 16, 10:50 (W4-7000)

Impacts of Ocean Acidification on early development of Antarctic krill

So **Kawaguchi**[1,2], Haruko Kurihara[3], Rob King[1], Akio Ishida[4], Masahide Wakita[4,5], Lillian Hale[6], Thomas Berli[6], James P. Robinson[6], Stephen Nicol[1], Patti Virtue[6] and Atsushi Ishimatsu[7]

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The Southern Ocean is believed to be one of the first marine ecosystems to be affected by Ocean Acidification (OA) due to the higher solubility of CO_2 in cold waters. Future rises in surface water pCO_2 would be further enhanced at depth where seawater pCO_2 is already higher than at the surface. Understanding the effects of increased pCO_2 on marine ecosystems will have to take into account the pCO_2 range already experienced by organisms and the likely changes that will be experienced throughout their life cycles. Antarctic krill (hereafter krill) is the key species of the Antarctic marine ecosystem, so there is a requirement to be able to make realistic predictions of the potential impacts of future acidification and warming on this species and the associated ecosystem ramifications. Krill lay eggs at the surface that sink 1000m before hatching; their early life stages then actively swim to the surface to feed phytoplankton (the developmental ascent). Our laboratory studies indicate embryos develop normally at 1000µatm but are almost totally inhibited at 2000µatm pCO_2. Model predictions suggest in some key parts of krill habitat the pCO_2 levels will reach up to 1400µatm by year 2100, possibly approaching levels where development may be inhibited. Further studies need to clarify where between 1000 and 2000µatm the impacts of pCO_2 levels begin to become manifest. We will further extend our discussion to how the OA might impact future distribution of krill, and identify the priority areas for the future study of OA impacts on krill.

March 16, 11:10 (W4-7187)

The effects of CO_2-induced ocean acidification on the survival and development of early larval stage Antarctic krill (*Euphausia superba*)

James P. **Robinson**[1,2,3], So Kawaguchi[2,3], Atsushi Ishimatsu[4], Haruko Kurihara[5], Rob King[3], Patti Virtue[1] and Stephen Nicol[2,3]

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The Southern Ocean may show the earliest signs of ocean acidification due to the higher solubility of CO_2 in colder waters. Research into the biological effects of elevated pCO$_2$ has focussed on the aragonite saturation state of seawater, which is essential to marine calcifiers including pteropods, foraminifera and many benthic invertebrates. Despite the critical importance of Antarctic krill as a key species of the Southern Ocean ecosystem, information on the effects of elevated pCO$_2$ on krill is very limited. Krill larvae hatch at ~ 1km depth and must complete a developmental ascent to the surface waters as they progress through the first four larval stages (nauplius I & II, metanauplius and calyptopis I). This study investigated the effects of elevated pCO$_2$ (380, 700, 950 and 2000 µatm) on these early larval stages. Significant effects were observed between 380 µatm and 2000 µatm, including a ~ 54% increase in mortality ($p<0.01$), a ~ 44% decrease in the proportion of larvae which successfully developed to calyptopis I and a ~ 72% reduction in the overall proportion of actively swimming larvae ($p<0.001$). The proportion of larvae surviving to calyptopis I with sufficient swimming ability to complete the developmental ascent decreased ~ 35% at 950 µatm and ~66% at 2000 µatm ($p<0.05$). Recent research suggests that pCO$_2$ at the depths associated with larval krill development may reach 1000 - 2000 µatm within this century. These results imply significantly reduced larval recruitment under elevated pCO$_2$ which would have major implications for Southern Ocean ecosystems and the krill fishery.

March 16, 11:30 (W4-7079)

Impacts of ocean acidification on the hatching success and larval development of *Euphausia pacifica*

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Euphausia pacifica is a critically important species in the secondary production of the California current, and thus it is valuable to determine the potential impacts of climate change on their ability to recruit. We carried out 5 experiments during the 2010 *E. pacifica* spawning season off of Oregon, USA, to assess the impact of lowered pH on their egg hatching success and early larval development. Gravid females were collected at night and returned to a laboratory cold room. Eggs were collected the next morning and broods were divided between a control (ambient pH) and three pH treatments with target pHs of 7.9, 7.6 and 7.2. Experiments were checked on day 3 in order to determine hatching success and day 8 in order to evaluate rate of development through the non-feeding larval stages. Initial results suggest that pH does not have a strongly significant impact on hatching success and development rate in this range of pH treatments. Unhatched eggs and deformed larvae were present, but both of these phenomena appeared to be more closely linked to maternal effects than to decreased pH. Further analysis will aim to clarify these relationships as well as to look at any differences observed as the spawning season progressed from June through September. Our results will be discussed in the context of expected cellular and environmental vulnerabilities for the planktonic crustaceans of the northern California current.

March 16, 11:50 (W4-6926)

Comparison of shell structure of two tropical species of thecosome pteropods (*Creseis acria* and *Diacavolinia longirostris*) over a 40-year period

Liza M. **Roger**[1], A. David McKinnon[2], Anthony J. Richardson[3,4] and Brenton Knott[1]

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Shelled pteropods (Thecosomata) are calcifying organisms that play an important role in the cycling of carbon in marine food webs. The uptake of anthropogenic carbon dioxide by the surface oceans affects calcifying organisms by increasing the dissolution rate of their aragonite skeletons. We studied two of the most abundant species of thecosome pteropods in Australian tropical waters: *Creseis acicula* and *Diacavolinia longirostris*. Specimens were collected from waters off the North West Shelf of Australia and the Northern Great Barrier Reef, Australia, between the early 1960s to the late 2000s. The aragonite shells from *C. acicula* and *D. longirostris* specimens were viewed under a high resolution Scanning Electron Microscope and the shell morphology, structure, size and porosity were compared to identify possible changes over the 40-year period. *C. acicula* and *D. longirostris* have very different shell morphologies, the latter being much more complex. Beyond the expected morphological differences between the two species, preliminary results suggest an increase in porosity and decrease in shell size over the period. The aperture width to shell length shows a linear relationship for *C. acicula* and *D. longirostris* specific to each species and constant over the years. An increase in shell porosity may be due to disturbance in the normal calcification mechanism resulting from a decline in pH over the 40-year period.

W5 Oral Presentations

March 16, 8:35 (W5-7254), Invited

In situ optical imaging of mesoplankton using the Video Plankton Recorder and digital holographic imaging

Cabell **Davis**

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In situ optical imaging of plankton is a powerful tool in biological oceanography. An overview will be presented of the methodology and scientific results from this technology, with examples from the Video Plankton Recorder and a prototype digital holographic camera. Images and data from a range of ocean regions will be shown to illustrate the overall utility of the technology in providing scientific insights. Comparisons with conventional methods will be shown, including discussion of sample volume, avoidance, non-invasive sampling, and time/space sampling resolution. A description of the methodology including calibration, image capture, feature extraction, classification, abundance and biomass estimation, and incorporation into models will be given. Technological challenges, scientific potential, and future directions will be discussed.

March 16, 9:00 (W5-7009)

Long term and spatial plankton monitoring with the ZooScan: Insights from a 6 years project at the Laboratory of Villefranche sur Mer and perspectives for a global network

Lars **Stemmann**[1], Franck Prejger[1], Corinne Desnos[2], Marc Picheral[2] and Gabriel Gorsky[2]

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The Observatoire and the Laboratoire Océanologique of Villefranche-sur-Mer (OOV and LOV respectively) owns one of the longest zooplankton time series in Europe. The sampling was initiated in 1958 and continues since 1966 on a daily basis using 2 or 3 nets (WP2 net with a mesh size of 200 µm, Juday Bogorov net with a mesh size of 330 µm, Regent net with a mesh size of 680 µm). The inventories of 50 years long series of meso-zooplankton (abundance, size measurements, biomass and functional groups estimates) are particularly suitable for the parameterisation of ecosystem models and for the study of their responses to climate and anthropogenic forcing. However, due to the amount of samples in the time series (>10,000), they were never manually counted for all the plankton community and studies have focused on specific target species. The RadeZoo service (http://www.obs-vlfr.fr/Rade/RadeZoo) at the LOV was established to analyse the plankton collection using the ZooScan. All samples are analysed using the same protocols in order to retrieve information from a minimum of 40 taxa and their biomass spectra. More than 4000 samples have been analysed this way. We will present the different protocols we have developed in order to rapidly analyze numerous samples in a minimum amount of time. We will also discuss the choices we made for taking full advantage of automatic image recognition and avoiding inevitable errors in prediction. We also introduce a basis for building a global network of taxonomists collaborating on digitalised plankton samples through the Internet.

March 16, 9:15 (W5-7192)

Comparison of winter fish eggs distribution in Eastern Channel and Southern North Sea derived from traditional microscopy and digitalized images analysis identification

Elvire **Antajan**, Stéphanie Lelièvre and Sandrine Vaz

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Studying spatial extent and location of fish spawning habitats is critical for understanding and forecasting fisheries recruitment evolution and will support ecosystem-based management. Recently, the development of a new laboratory imaging system, the ZooScan, capable of obtaining relatively good resolution images makes possible automated zooplankton identification using supervised learning algorithms. This new approach was applied on formalin-fixed fish egg samples collected by the CUFES (Continuous Underway Fish Eggs Sampler) during the winter 2009 IBTS (International Bottom Trawl Survey) surveys in the Channel and the Southern North Sea. Automatic recognition of seven fish egg species (dab, flounder, rocklings, whiting, cod, plaice and long rough dab) was compared with results of the visual identification in order to validate the method of training. Abundance and distribution maps of winter spawning areas of plaice, long rough dab, cod and whiting based on microscope and ZooScan identifications were similar. For some species having the same range of egg diameter, as for dab and flounder, the confusion was important. The presence of oil globules, as for rocklings, is not taken into account by the ZooScan, which explained that this species are badly identified by the ZooScan and confused with other species of similar size class (dab and flounder). The potential of such tool to quickly acquire valuable data on identification, enumeration, and size frequency distribution of fish eggs and map spawning areas was proved in this study.

March 16, 9:30 (W5-7223)

New methods for using a continuous imaging particle analyzer (FlowCAM) for the analysis and classification of zooplankton

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Monitoring the health of marine and freshwater systems and tracking environmental change requires a knowledge and understanding of the system's phytoplankton and zooplankton communities. A major drawback of plankton monitoring using microscopy for identification and enumeration from samples is the amount of time required for preparation and analysis. Determining zooplankton abundance and analyzing zooplankton size is important when identifying the dominate primary producers in an aquatic system. Here we present updated information on the continuous imaging particle analyzer (FlowCAM). Initially developed in 1999, the FlowCAM is being used globally to study and analyze both phytoplankton and zooplankton. Recent activities at Fluid Imaging Technologies, developer and manufacturer of the FlowCAM, on design changes and methods development have improved the instrument for the analysis of large particles up to 2 mm in size. An overview of the technology will be given, including a review of the design changes and presentation on optimal methods for the analysis of zooplankton using the FlowCAM.

March 16, 9:45 (W5-7334)

Zooplankton biomass size spectra off Rio de Janeiro (Brazil) estimated by LOPC and Zooscan observations

Catarina R. **Marcolin** and Rubens M. Lopes

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Novel *in situ* and laboratory-based optical systems have emerged in recent years as valuable tools to automatically detect and measure plankton. In this study, we used a LOPC and a ZooScan to evaluate zooplankton abundance and biomass off Rio de Janeiro, Brazil. Vertical profiles with a LOPC and a 200-µm plankton net were performed at 24 stations on the outer shelf (~100-m depth) during April 2010. Regression slopes derived from the normalized biomass size spectra (NBSS) provided by the LOPC ranged from -0.86 to -0.66 and were similar among stations. Maximum particle abundance were related to the lowest size range detected by the LOPC (100-250 µm) comprising more than 75% of total counts, but larger particles (>500 µm) accounted for most of the biomass. Zooscan analysis showed that subdominant large-sized taxa such as cnidarians, chaetognaths and doliolids contributed to the bulk of biomass while small-sized taxa (*e.g.* calanoids, gastropods) were numerically dominant. Although size detection is not entirely coincident in these instruments, both the LOPC and the Zooscan provided useful and rapid results on zooplankton vertical distribution in the study area.

S4 Oral Presentations

March 16, 14:05 (S4-7208), Invited

Does individual variability matter in small-scale interactions involving zooplankton? Observations and considerations from ichthyoplankton field studies

John F. **Dower**[1] and Pierre Pepin[2]

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Over the past few decades, much has been learned about small-scale interactions involving zooplankton. For instance, high-speed videographic techniques have documented foraging behaviours and prey selection, routine swimming mechanics, initiation of escape responses, swarm formation, and the mating behaviours of various taxa. On the physical side, the role of micro-scale turbulence in the predator-prey encounter/capture process has been explored empirically and via modeling studies, with some corroborating observations from field studies. Likewise, we now have a better understanding of the various chemosensory cues that zooplankton use to detect food, find mates, and sense and avoid predators. Typically, such studies involve fine-scale observations of individual zooplankton (mostly copepods) under highly controlled lab conditions. In contrast, most zooplankton taxa are never studied at the individual level under natural field conditions. A key exception to this are the ichthyoplankton; field studies of larval fish regularly collect data at the individual level through the use of tools such as gut content analysis, otolith microstructure, and RNA:DNA ratios. Here, we examine what such field studies have revealed about the role of individual variability in generating larger-scale patterns of growth, survival and distribution of ichthyoplankton. We also consider the implications of these findings for other groups of zooplankton, and whether similar approaches might be developed for future field studies.

March 16, 14:30 (S4-6956)

Depth keeping by swimming against the flow in zooplankton: Adaptive benefits and ecological implications

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Many zooplankters maintain their depth by swimming against vertical currents, thereby forming immense aggregations along oceanic fronts. The adaptive benefit of this behavior, however, is unknown. Here we propose a link between depth-keeping, lipid content (density), and feeding biology in copepods. To generate effective feeding currents, the difference between the density of the animal and the water around it should be fixed (hereafter “dRo”), species-specific. Thus, because lipids are more compressible than water, individuals that do not keep depth during downwelling (or upwelling) would reach depths where their dRo would change only because of changes in pressure. Furthermore, since water density increases with depth, individuals that differ in their density are expected to seek different depths. Our sampling between 5 and 70m depths showed that *Ctenocalanus vanus* and *Mecynocera clausi* copepods with more lipids were found at greater depths. In addition, we found a significant lipid-content dependent effect of pressure on sinking velocity in *Rhincalanus nasutus*. In contrast to our expectation, when high pressure (3.5 bars) was applied, the sinking velocity of individuals with high lipid content decreased, rather than increased. No pressure effect was observed for low-lipid individuals. These results support our hypothesis that lipid content and pressure affect the density of copepods. An ensuing effect of pressure on their feeding, if observed in our forthcoming work, will explain not only the benefits of depth retention but also the factors that influence the selection of foraging depth by different individuals.

March 16, 14:50 (S4-7172)

Mechanoreceptive hairs: How do they work?

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Zooplankton responds to chemical and fluid mechanical signals in the water column. These behavioral responses govern individual processes such as mating, feeding and avoiding predation. Individual behaviors also are the underlying drivers of population level distribution patterns in the environment leading to patches near ocean fronts, along density gradients or within light shafts. For these behaviors to occur organisms must detect and respond to environmental cues. These cues are collected by their sensors with each individual receptor acting as a broadband filter for biologically relevant signals. As a result, the suite of potential signals is determined by characteristics of individual sensors and the architecture of the entire sensory system. Because sensory neurons frequently are tuned to preferentially detect biologically significant signals, understanding the characteristics of sensors offer valuable insight into the information that governs the organism's behavior. The purpose of this contribution is to discuss current knowledge about the mechanosensory structures of marine copepods as a case study for understanding sensory ecology from a structure–function vantage point.

March 16, 15:10 (S4-7114)

Toward a mechanistic understanding of the jumping behavior of copepods

Houshuo **Jiang**[1], Thomas Kiørboe[2] and Sean P. Colin[3]

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Jumping is a widespread behavior observed for planktonic copepods. Those copepods typically perform powerful and rapid escape jumps upon being made aware of approaching danger. Some copepods execute carefully maneuvered jumps when attacking prey. Some small copepods (prosome length typically less than 1mm) frequently relocate in the water column by short and less powerful upward jumps. Some small cyclopoid copepods swim by striking the swimming legs posteriorly; a consecutive train of such small jumps enables the copepods to travel a significantly long distance. Copepod nauplii also exhibit jumps to avoid being preyed upon and to relocate themselves. Significant questions have been raised about whether jumping is energetically more costly or hydrodynamically more dangerous (*i.e.* more easily detectable by rheotactic predators) than other behaviors such as creating a feeding current or cruising. To answer these questions, we have conducted a comprehensive investigation of copepod jump-imposed flows by using a combination of theoretical hydrodynamic modeling, particle image velocimetry (PIV) measurements, and empirical data-driven computational fluid dynamics (CFD) simulations. We found that near impulsive generation and viscous decay are two key characteristics of the jump-imposed flows with importance for the jumping behavior of copepods. In this talk, we will present the results on the spatiotemporal flow-field patterns and decay rates of the copepod jump-imposed flows and jump energetics and efficiency. The ecological implications of these results will be discussed by comparisons with other important behaviors.

March 16, 15:30 (S4-7333)

Behavioral responses of *Temora turbinata* (Copepoda, Calanoida) exposed to phytoplankton thin layers

Luis Fabiano Baldasso[1], J. Rudi Strickler[2] and Rubens M. **Lopes**[1]

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Phytoplankton thin layers have been increasingly recognized as significant fine-scale structures in pelagic systems, yet their impact on zooplankton behavior and production is still poorly understood. Here we investigated with a benchtop video system the swimming responses of *Temora turbinata* to thin (centimeter scale) microalgal layers containing toxic dinoflagellates, *Alexandrium tamiyavanichii* Balech 1994, and non-toxic prasinophytes, *Tetraselmis gracilis* (Kylin) Butcher. Copepods exploited both toxic and non-toxic thin layers as feeding sites, but their swimming performance differed between food types. Compared to non-toxic algae, exposure to toxic *Alexandrium* led to increased swimming speeds and more complex trajectories during initial (~10min) exposure, followed by decreasing activity. We concluded that planktonic copepods are able to sense and explore even quite narrow layers, and that changes in layer floristics have a noticeable impact on copepod behavior.

March 16, 16:20 (S4-7206)

Predator prey interactions in the plankton: Linking microscopic behaviors to population dynamics

Susanne **Menden-Deuer**

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Planktonic organisms, from bacteria to larval fish, have elaborate behaviors that aid their reproduction, survival and resource acquisition. A major challenge lies in linking microscopic, often species-specific, characteristics with their ecological ramifications at the population or ecosystem level. Integrating empirical data with theoretical modeling studies can help identify mechanistic linkages between microscopic causes and macroscopic consequences. I will highlight recent research results that include: 1) laboratory experiments detailing effective predator defense mechanisms that promote the survival of harmful algal bloom species; 2) empirically verified model simulations that mechanistically link individual motility patterns with population dispersal distances; and 3) empirically derived estimates of predator prey encounter radii. Finally, I will present data that highlight the quantitative importance of protistan trophic and demographic rates to the formation and persistence of plankton patches. Overall, these results support the hypothesis that individual movement and foraging behaviors have a significance impact on large-scale patterns in plankton abundance, distribution and population dynamics.

March 16, 16:40 (S4-7298)

Quantification of plankton and marine snow in the Gulf of Mexico during summer 2010 using the Video Plankton Recorder

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The color digital autonomous Video Plankton Recorder (DAVPR) was used to sample plankton and marine snow in the near and far field regions of the Deep Water Horizon oil spill in summer 2010. Stations were sampled along transects SW of the wellhead up to 300km away. Repeated vertical profiles were made from the near surface to 1200m depth. A 1m v-fin was mounted to the DAVPR frame, and the system was towed at a speed of 2 knots on 20km transects running perpendicular to the continental slope. The DAVPR system also included a CTD, chlorophyll fluorometer, and turbidity sensor. The DAVPR-vfin system was mounted on a Seabird 911 CTD frame that also included an Aquatracka crude oil fluorometer. Vertical and horizontal distributions of plankton, marine snow, fluorescence, and environmental variables will be presented. The DAVPR data includes abundance and biomass of major taxa and particles. The relationship with physical dynamics of the system and the modeled spread of the oil plume will be discussed.

S5 Oral Presentations (Day 1)

March 16, 14:05 (S5-7489), Invited

Zooplankton in upwelling and coastal systems

Rubén **Escribano**

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Although upwelling and coastal systems constitute a small fraction of the global ocean (<2%), they are key regions where intense biological activity, strong land-ocean and coastal-ocean interactions, and enhanced air-sea exchanges converge. In these systems, zooplankton (covering a wide range of heterotrophs) play a pivotal role by channeling phytoplankton C through the pelagic food web and, at the same time, it constitutes a large, and not yet fully estimated, C reservoir of the ocean system. Zooplankton populations and communities in upwelling and coastal systems must cope with a wide range of physical and chemical variability given the high heterogeneity of these habitats, both in space and time. Thus, physiological and behavioral adaptations in zooplanktonic organisms exhibit a variety of solutions to confront the strong physical and chemical gradients in the water column. Our knowledge on zooplankton dynamics in upwelling and coastal systems has greatly improved in the last two decades, and it seems that increased awareness about the ecological importance of zooplankton for understanding marine ecosystem responses to climate change has a been a key factor prompting research on plankton dynamics. Climate change, forcing oceanographic variability, is now considered a main driver of the fluctuations in zooplankton biomass, dynamics and diversity in the oceans. For instance, evidence suggests that wind-induced coastal upwelling is a main factor associated with changes in zooplankton production and composition. In this work, recent findings on the mechanisms connecting zooplankton dynamics and their physical and chemical environment will be addressed and discussed. New questions and hypotheses will also be presented, together with a proposition on new lines of research and challenges for the coming decades regarding zooplankton ecology in upwelling and coastal systems.

March 16, 14:30 (S5-7198)

Long-term and interannual variability of zooplankton at a coastal station in the Western English Channel

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We investigate interannual changes in the trend and seasonality of zooplankton time series data from a coastal station in the western English Channel. Selected taxa were analysed with Dynamic Harmonic Regression (DHR) models that allow the phases and amplitudes of the seasonal components, as well as the trend, to vary over time, thereby eliminating arbitrary choices of seasonal component frequencies. The model was applied for total zooplankton, the calanoid copepods *Centropages typicus* and *Temora longicornis* and two meroplankton taxa (bivalve and decapod larvae). Comparisons with computations for total phytoplankton abundance, as well as diatom and dinoflagellate abundance and biomass explore potential trophic relationships between zooplankton grazers and prey availability and quality. All zooplankton taxa studied showed marked interannual variability. Total zooplankton peaked in spring and again in late summer with no evident long-term trend. However, a significantly negative trend of zooplankton abundance in the mid 1990s, evident also in the data of individual taxa, coincided with positive trends in total phytoplankton abundance, including diatoms and dinoflagellates. The model thus identified periods with potentially significant shifts in trophic relationships between phytoplankton and grazers. The role of abiotic drivers, such as temperature and nutrients, for these relationships is discussed.

March 16, 14:50 (S5-7154)

The life history strategies of *Calanus sinicus* in the continental shelf ecosystem

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The copepod *Calanus sinicus*, which dominates the zooplankton assemblage in the Yellow Sea, provides the main food for several economically-important fishes; therefore its population dynamics will affect the fishery resources. The functional role of *C. sinicus* in the Yellow Sea and East China Sea is comparable to that of *Calanus finmarchicus* in the North Atlantic, yet before now, our 10-year endeavor had only elucidated its population dynamics and life history, which are of major importance to understand the functioning of the Yellow Sea marine ecosystem as well as the fishery fluctuations. Based on data from the last 10 years, the seasonal and regional variations of *C. sinicus* population distribution, biomass, reproduction and recruitment were studied in relation to the temperature, food supply, water mass, fronts and lipid reserve. With favorable food conditions, spring recruitment was high and critical for the annual population dynamics, producing populations with high lipid reserves for the summer dormancy in the Yellow Sea Cold Water Mass (YSCWM), where the over-summering population would decline as *C. sinicus* decreased feeding and ceased reproduction until late autumn-early winter. In autumn, the population gradually recovered, especially in frontal areas where food conditions were better. Winter recruitment was low but adequate to sustain the population, probably because of their low metabolic rate and mortality under low temperature. Overall, the over-summering strategy, as well as the physiological and behavioral changes such as high lipid reserves, periods of non-feeding, and gonad immaturity seemed essential in the population dynamics of *C. sinicus*.

March 16, 15:10 (S5-7102)

Is there enough zooplankton to feed forage fish population off Peru? An acoustic (positive) answer

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The Northern Humboldt Current system (NHCS) produces more fish per unit area than any other region in the world. Although the system produces enough macrozooplankton to sustain its high production of forage fish, the paucity of information on macrozooplankton hampers research into the system. In this study, we estimated the biomass of the epipelagic crustacean macrozooplankton from the NHCS during austral summer and spring 2005. To do this, we developed a bi-frequency acoustic method and extracted high-resolution information on the biomass and the patterns of distribution of crustacean macrozooplankton, fish and other marine compartments. We found that, although macrozooplankton comprises a number of distinct organisms, the euphausiids were the zooplankton group that best fitted the patterns from independent net sampling zooplankton data. Total macrozooplankton biomass was estimated to be about110 g m^{-2}, *i.e.* two to five times more than previous estimates. This new independent estimation of high macrozooplankton biomass is in agreement with new findings in trophic ecology indicating that forage fish consume mainly macrozooplankton. This high biomass also supports the current hypotheses explaining the NHCS high fish production. We are able to revisit present-day and historical acoustic databases and extract high-resolution data on macrozooplankton, a key ecological compartment of the ecosystem. Since zooplankton is the link between the physically-driven primary producers and the biologically-driven tertiary consumers, this information is essential to achieve a mechanistic understanding of the system, from physics to top predators.

March 16, 15:30 (S5-6985)

The presence of distinct offshore planktonic communities in coastal British Columbia inlets

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British Columbia coastal fjords or inlets are subject to both offshore and coastal oceanographic and terrestrial influences, creating unique biological habitats. Several BC inlets have deep (up to 850 m), isolated channels with glacial fresh water input that drain into the relatively shallow Strait of Georgia (maximum depth 350 m). The Strait of Georgia provides a conduit to both coastal and offshore waters. Plankton surveys conducted within selected coastal inlets from the last two decades have revealed the presence of several common offshore or open ocean species that have established viable populations within these inlets. These same populations are absent from the coastal waters, and in most cases, are also absent from the transportation exchange mechanism provided by the Strait of Georgia. We identified 12 species that were present in both offshore and inlet stations, but were not typically considered coastal ocean species. These included calanoids (e.g. *Neocalanus* sp., *Metridia pacifica*, *Calanus pacificus*, *Oithona atlantica*), hyperiids (*Primno abyssalis*), euphausiids (*Thysanoessa longipes*) and ostracods (*Conchoecia magna*). We discuss the established inlet and offshore plankton populations along the BC coast and explore possible transportation mechanisms. Documenting how these plankton populations have immigrated and maintained their status in these oceanographically unique inlets may help to understand how ballast-water transported, non-indigenous species, may establish in these locations as well.

March 16, 16:20 (S5-7151)

Interannual variability in nitrogen dynamics and zooplankton structure in the northern range of the California upwelling system

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Zooplankton composition in the California upwelling system correlates with broad shits in climate, but mechanisms explaining these correlations are poorly understood. Stable isotopes (15N and 13C) of zooplankton are determined by both nutrient sources and food web structure, and as such have the potential to elucidate links between climate, nutrient dynamics and zooplankton. We present a time-series (1998-present) of zooplankton stable isotopes collected from the northern range of the California upwelling system (the west coast of Vancouver Island) and adjacent coastal regions. Seasonal trends in zooplankton 15N and 13C are driven primarily by local nitrate utilization and phytoplankton productivity and to a lesser extent by zooplankton composition. Interannual patterns in stable isotopes, however, appear to be driven by large-scale fluctuations in climate and oceanographic conditions. Nitrogen isotopes correlate with indices of local temperature and the PDO, whereas 13C correlate with upwelling strength. Nitrogen isotopes also correlate with biomass anomalies of southern copepods, while 13C correlate with biomass anomalies of subarctic copepods. Interannual variability in stable isotopes reflects horizontal advection of nutrient-poor, 15N-rich equatorial waters as well as lipid content of advected zooplankton assemblages. Using these findings, we develop a conceptual model linking nutrient dynamics and zooplankton structure in coastal upwelling regions, and explore how these patterns differ in estuarine (Strait of Georgia) or coastal downwelling domains (Southeast Alaska). Our results highlight the potential of integrating biochemical parameters in zooplankton time-series in elucidating mechanisms of biophysical coupling in the ocean.

March 16, 16:40 (S5-6892)

Comparing the hydrography and copepod community structure of the continental shelf ecosystems of Washington and Oregon, USA from 1998 to 2009: Can a single transect serve as an index of ocean conditions over a broader area?

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Bi-weekly sampling of zooplankton and environmental parameters was conducted along a cross-shelf transect off the coast of Newport, OR, USA (44.65ºN) from 1996 to present. Results have demonstrated the feasibility of using copepod community structure as an early indicator of ecosystem response to seasonal and large scale environmental changes in the Northeast Pacific. Spatial surveys of hydrography and zooplankton have also been completed along multiple cross-shelf transects from the central Oregon coast northward to the northwest corner of Washington (45-48ºN) every May, June, and September since 1998. Although both sampling programs are located in the productive Northern California Current, questions have arisen as to the spatial comparability of zooplankton data, thus we tested the idea that data from a single transect can serve as an index of ocean conditions over a much broader area. That is, how feasible is it to make ecosystem forecasts from a single high-frequency data set (Newport) compared to more extensive but less frequent spatial surveys? Comparisons will be made using the environmental parameters (stratification, upwelling strength, chlorophyll concentration) and copepod community structure, including spatial variations, inter-annual variability, and the effect of basin scale climatic events (*e.g. El Niňo*, PDO phase). Regional analysis of environmental parameters allows insights into the relative importance of spatial variations in environmental variables in shaping copepod community structure and therefore the lower trophic level ecosystem.

March 16, 17:00 (S5-7174)

Variability of the zooplankton community in the Northern Humboldt Current System (2007-2009) and its relation to physical forcing

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Since zooplankton is the main food source for Peruvian anchovy (*Engraulis ringens*), a better understanding of the variability of the zooplankton distribution and abundance in near-coastal regions is of great interest. We analyzed the zooplankton community in three near-coastal areas of the Northern Humboldt Current System, off Paita (05°00'S), San Jose (06°50'S) and Callao (12°00'S). In these three areas, cross-shore sections consisting of 4 stations were sampled every 2 months in 2007-2009; zooplankton was collected at the surface with a WP-2 net. The highest levels of zooplankton biovolume and abundance were observed off Paita and the lowest at San Jose. Marked seasonal cycles were observed off Callao and Paita, with lowest (highest, respectively) levels occurring in winter (summer). Copepods were the most dominant group (~70-90%), but euphausiids and decapod larvae also contributed significantly in abundance and biovolume off Paita. Off San Jose and Callao, *Acartia tonsa* contributed 90% of the abundance and biovolume, whereas in Paita both *Acartia tonsa* and *Calanus chilensis* dominated the abundance. *Acartia tonsa* decreases its abundance with the presence of Subtropical Surface Water (STSW). Diversity measures were highest in Paita and lowest in San Jose, which suggests that the latter may be used as an indicator area to detect changes in the environment. The observed spatio-temporal variations are to some extent related to physical forcing such as upwelling and turbulence intensity (stronger in winter and weaker in summer), and water mass distribution (presence of Cold Coastal Water and intrusions of STSW).

March 16, 17:20 (S5-7010)

Abundance and mortality of the larvae of the green crab *Carcinus maenas* in the Bay of Cascais, northeastern Atlantic

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The distribution, abundance and mortality of *Carcinus maenas* larvae was studied between February 2005 and June of 2007 at a coastal station off Cascais Bay, Portugal (38º40´N 09º26.2´W). Plankton samples were collected monthly from oblique tows using a WP-2 net with 180µm mesh size. At the same time, environmental parameters such as temperature, salinity and fluorescence were collected (CTD and fluorometer). Monthly precipitation was measured from Lisbon's IGIDL (Instituto Geofísico do Infante D. Luis) meteorological station, and upwelling index values were obtained from PFEL (Pacific Fisheries Environmental Laboratory). All larval stages were present in the samples each year from October to June, the first zoeal stage being the most abundant (up to 154 ind. m^{-3} in March). *C. maenas* larvae presented a clear seasonal pattern with highest abundances in early spring (March/April) for three consecutive reproductive seasons. A Spearman non-parametric correlation analysis applied to larval abundances and environmental parameters revealed a positive correlation ($p<0.05$) with Chl-*a* concentration. A method to estimate total mortality between zoeal stages was developed and is presented. Results from the application of the method demonstrate that total mortality varied from 45 to 85% for first stage zoeae and was greater than 80% for older stages.

March 16, 17:40 (S5-7235)

Variability in copepod communities in the northern Benguela upwelling region from 2000 to 2010

Anja **Kreiner**[1] and Dawit Yemane[2]

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Zooplankton has been collected during regular monitoring cruises along transects off the Namibian coast for one decade. Copepods, the most abundant mesozooplankton, show high seasonal as well as interannual variability throughout the time series. Considering the importance of copepods as an important prey to sardine and other pelagic dependent species, long term monitoring studies of this type are relevant to understand the dynamics of both the important resource species and that of copepods in light of changing environmental conditions. *Oithona sp*. is the numerically most abundant copepod in the study region with *Metridia sp*., *Calanoides sp.*, *Centropages sp*. and *Nannoclanaus sp.* being the other dominating species. Results from generalized additive modeling show that distance from shore has an effect on the abundance of all species investigated, while month, temperature and oxygen are other important predicting parameters. Proportions of the dominating species change interannually as well as between the shelf and the offshore region. After reaching peak levels of abundance between 2002 and 2004, copepod abundances have declined and are closer to long term averages. Spatial distribution along the monitoring transect at 23°S, which is located within the main spawning area of sardine, varies seasonally and annually. Temporal and spatial variability in copepod abundances and community structure are discussed in relation to environmental parameters collected during the monitoring surveys. Furthermore, possible linkages between sardine recruitment and copepod abundances and distributions have been investigated.

S5 Oral Presentations (Day 2)

March 17, 8:40 (S5-6931)

Zooplankton in the southeast Pacific upwelling: Diversity and vertical distribution derived from an optical imaging system and automated image analysis

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High productivity of upwelling regions is based on efficient food web transfer from primary producers through zooplankton to higher trophic levels. Trophodynamic efficiency depends on close spatial coupling between predator and prey. Understanding the functioning of upwelling systems therefore requires knowledge on spatial scales and ecophysiological controls of the vertical distribution of the various components. Our goal was to study vertical distribution of zooplankton in relation to environmental conditions with high resolution and to define taxon-specific habitats. On transects across the Peruvian shelf, environmental parameters (T, S, O_2, fluorescence) and zooplankton distribution were studied in the upper 600m with LOKI, an optical plankton sensor for high resolution investigations. Strong gradients characterized the water column. A pronounced oxycline (<50 µmol Kg^{-1}) was located between 6 and 160m. Ca. 34 taxa were identified from images, while ca. 98 taxa were found in concurrent samples. A large number of zooplankton taxa were found in the oxygen minimum zone (OMZ). Descriptions of preferred environmental conditions were established for a variety of taxa, including O_2 tolerance. Training sets were tested against different algorithms for automated image analysis. The study demonstrates the potential of new instrumentation with regard to providing information on distribution and rapid sample analysis using imaging systems, even in regions with high biodiversity.

March 17, 9:00 (S5-7038)

High resolution of macrozooplankton biomass distribution in relation to the depth of the upper oxygen minimum zone off Peru

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Acoustic techniques recently developed in the northern Humboldt Current system off Peru provide estimates of both macrozooplankton (mainly euphausiids and large copepods) biomass and upper oxygen minimum zone (OMZ) depth at very high resolution (one data per second along the survey tracks). With such information the volume of epipelagic habitat, as constrained by the upper limit of the OMZ, can be precisely evaluated. We applied this method to acoustic data collected during 6 surveys performed from 2005 to 2008 along the Peruvian coast. Since we focus on macrozooplankton distributed in the epipelagic layer we considered day and night data independently; night data corresponded to both vertically-migrating and non-migrating zooplankton. We used this unique dataset to show how the depth of the upper OMZ, a proxy of underlying physical processes, shapes macrozooplankton distribution. In particular, we achieved 3D reconstructions of the epipelagic habitat off the Peruvian coast and projected macrozooplankton distribution in these volumes. Satellite data were used to reveal surface features such as fronts, eddies and upwelling plumes. Results show that macrozooplankton biomass hot spots are associated with downwelling/convergence structures, indicating strong bottom-up structuring processes in a continuum of spatial scales. This approach, which could be implemented in other upwelling ecosystems, provides a series of perspectives to improve knowledge on (i) ecosystem structure and function and (ii) biogeochemical, trophic and/or ecosystem models.

March 17, 9:20 (S5-7129)

Population dynamics of the euphausiids *Euphausia pacifica* and *Thysanoessa spinifera* in the upwelling region off Newport, OR, USA

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Climate change scenarios suggest that global warming may lead to changes in the strength of coastal upwelling and changes in the magnitude and duration of natural climate cycles such as the PDO. Our biweekly zooplankton sampling (1996-present) encompasses variations in timing and intensity of upwelling and cool and warm phases of the PDO which allows us to investigate some potential effects of climate change on the euphausiids *Euphausia pacifica* and *Thysanoessa spinifera*. *E. pacifica* spawning is strongly associated with the timing of the onset of upwelling but not with upwelling strength. Spawning peaks four months after the spring transition and juveniles appear two months later. In 2005 upwelling was delayed and krill spawning was similarly delayed. Survivorship of larvae produced that summer was considerably lower than during other years. *T. spinifera* spawn prior to and during upwelling and seem to be more strongly affected by water temperature. 2002 was an anomalously cold year and *T. spinifera,* usually a shelf species, was found far offshore. Their reproductive effort in 2002 was the highest seen during this study. *E. pacifica* were not strongly affected by the temperatures they experienced during this study and were always present. *T. spinifera* were rare or absent during warmer ocean conditions. Changes in the timing of the spring transition are likely to affect *E. pacifica* spawning behavior. Consistently warmer ocean temperatures will likely lead to a decrease in *T. spinifera* abundance and spawning. Both scenarios will affect the availability of euphausiids to higher trophic level predators.

March 17, 9:40 (S5-7222)

Swarms of the salp *Thalia democratica* off south-eastern Australia: The interaction of oceanography, fecundity and growth

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Salps are the fastest growing multicellular animals on the planet. With rapidly sinking faeces and a comparatively large size, they potentially have a major role in the ocean's carbon flux. Salps are relatively unstudied in Australian waters since the work of Heron and others over 20 years ago. During the Austral Spring (October) of 2008 and 2009 we sampled the dynamic region to the south of the East Australian Current Separation Zone. Dense blooms of *Thalia democratica* were observed across the continental shelf, but particularly within a coastal cold-core eddy. An Optical Plankton Counter, undulating between the surface and 120m was towed though the centre of a cold-core eddy, recording counts of ~8000 ind. m^{-3} of zooplankton in a 10km wide subsurface layer (20-40m) at the centre of the eddy, relative to <1000 ind. m^{-3} at the edge. Up to 75% of these are believed to be *T. democratica* based upon size distribution and community composition analysis from nearby net samples, meaning this is the highest abundance of *T. democratica* measured in south-east Australian waters. The fecundity of *T. democratica* during these sampling periods is also assessed from laboratory studies in order to understand the mechanisms for bloom development. The size and number of buds released by the solitary form of *T. democratica* was observed in tanks, and numbers and lengths of internal buds before release was measured from preserved net samples.

March 17, 10:30 (S5-7099)

The role of chaetognaths in trophic carbon cycling in the central-southern Humboldt Current System off Chile

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Carbon flow through the chaetognath *Sagitta enflata*, one of the most abundant zooplankton predators, was estimated over a 3-year period of monthly sampling in the coastal upwelling region of the Humboldt Current System. In addition, the abundance, feeding rate, growth rate and predation impact on the zooplankton community was estimated at a fixed station off Concepcion, Chile (36º30´S 73º07´W). During periods of high zooplankton biomass (winter to summer), *Calanus chilensis* contributed substantially to total zooplankton biomass and was the main carbon source for *S. enflata,* accounting for ~50% of its daily carbon intake. The daily removal of secondary production (SP) as zooplankton prey items (at species or genus level) was usually less than 4%. During periods of low plankton biomass, feeding rate was focused on *Paracalanus indicus, Oithona* spp., *C. chilensis* and small unidentified copepods which accounted for 52, 17, 4 and 20% of total prey ingested. During this period *S. enflata* consumed a larger fraction of the daily SP of *P. indicus* (14%), *C. chilensis* (20%), *Centropages brachiatus* (14%) and *Acartia tonsa* (8%). Despite the high biomass of *S. enflata* (~10% of total zooplankton biomass) the carbon generated as tertiary production was relatively low (2.6% of total zooplankton SP). This was mainly a consequence of the low carbon specific growth rate (~0.02d^{-1}) estimated for this species. These results suggest that a substantial amount of zooplankton SP can be channelled through *S. enflata* in low productive periods, decreasing the carbon transfer towards other pelagic carnivores, as it probably acts as a trophic "dead end".

March 17, 10:50 (S5-6927)

Comparison of chaetognath assemblages along the Pacific Coast and adjacent inland waters of the Philippines: Biological indicators of water mass movement

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The pelagic environment plays an important role in shaping distribution patterns. When studying plankton distribution, it is essential to investigate the biology of the target organisms and the surrounding physical environment. Station and species groupings are only useful if they provide insights into the environmental associations of the species in the group. Our study covers two geographical regions: the Pacific Coast (Bicol Shelf) and Inland Waters (San Bernardino Strait, Ticao Pass, Sibuyan and Visayan Seas). We provide comprehensive information on the chaetognath assemblages, distribution and ecology within these regions. We then attempt to integrate our findings with large-scale oceanographic conditions and phenomena that define the character of each sub-area, as well as how these oceanographic conditions affect the manner in which chaetognath ecology is shaped. We further provide a comparison of the community structure of the two regions, and explore the possible use of chaetognaths as indicator species of water mass movement and oceanographic phenomena. In total, 28,284 specimens were examined, and 33 species from 17 genera were identified from the 77 stations sampled. Chaetognath distributions, abundance, and community structure were analyzed using dissimilarity indices and multiple regressions. The results reveal good correlations between species distributions and oceanographic factors. Based on chaetognath environmental preferences and distribution as reported in the literature, our results indicate an apparent influx of oceanic water from the Pacific into the inland waters of the Philippines.

March 17, 11:10 (S5-7216)

Vertical structure of copepods in the Northern Humboldt Current System (6°-8°S) during February 2008

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This work investigates the vertical distribution of copepods in the Northern Humboldt Current System (NHCS) based on the analysis of zooplankton samples and concomitant hydrographic properties collected during the *Filamentos* cruise in February 2008. Twenty multi-disciplinary stations were occupied along cross-shore sections (3 nm to 120 nm from the coast) located in an upwelling region of the NHCS (6.5°S-8°S). At these stations, zooplankton samples were collected in 9 stratum of the water column (500-0m) using a Multinet.

Of the 146 copepods species identified, 4 (8, respectively) comprised >80% (90%) of the total abundance. The highest abundances of these species were observed in the upper layer (0-50m) which corresponded to the well-oxygenated (~7 mL L^{-1}) mixed-layer. In the offshore ocean, some of these species, namely *Eucalanus inermis*, *Paracalanus parvus* and *Oncaea venusta*, also vertically migrated to 500 m depth, into the core of the Oxygen Minimum Zone associated with Equatorial Subsurface Water. On the continental shelf, *Paracalanus parvus* and *Acartia tonsa* were the most abundant, and were associated with algal blooms. However, *Acartia tonsa,* which is generally observed only over the shelf, was also encountered in the offshore ocean between 300 and 400m depth. The unusual copepods distribution observed in a Peruvian coastal upwelling region is partly related to the regional water-mass characteristics and circulation documented during the multi-disciplinary *Filamentos* cruise. Further studies are however needed to clarify the impact of the near-coastal dynamics on the copepod behavior in the NHCS.

March 17, 11:30 (S5-7109)

Is zooplankton grazing an important pathway of C through the pelagic food web in a highly productive coastal unwilling system?

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The ecological role of herbivorous zooplankton has been challenged lately on the grounds that a heterotrophic pathway of C (microbial loop) predominates in the ocean, and this may even be true in coastal upwelling zones, which were traditionally viewed as controlled by a classical zooplankton-phytoplankton food chain. To examine this suggestion for the coastal upwelling zone off Chile, we used the gut fluorescence method to assess the impact of zooplankton grazing, for a variety of supposedly herbivorous species, on phytoplankton C and on primary production, covering cross-shelf, alongshore and temporal (seasonal) variation during 2008-2009. Stratified zooplankton sampling allowed us to estimate grazer abundances, while direct measurements of Chlorophyll *a* and particulate organic C were used to assess phytoplankton biomass. Main grazers were dominant species of copepods and euphausiids and phytoplankton C ranged from 0.02–6.5 g C m^{-3}. For both upwelling conditions (spring-summer) and non-upwelling (fall-winter), the water-column integrated impact of grazing did not reach more than 5% of the phytoplankton C which is ~1% of the daily primary production during the spring-summer. Although large-sized calanoid copepods, such as *Calanus*, *Rhincalanus* and *Eucalanus*, and the dominant "krill", *Euphausia mucronata*, feed mostly on diatoms, they are largely outnumbered by small-sized copepods (calanoids and cyclopoids), whose diet is mainly comprised of heterotrophic nanoplankton and microplankton. These small copepods may thus control the C flux through the food web via heterotrophy in this costal upwelling system. The role of large-sized grazers, including calanoid copepods and euphausiids may require revision.

March 17, 11:50 (S5-7158)

Characterization of plankton communities and *Acartia* reproductive traits related to environmental conditions in the Guadiana river estuary and adjacent coastal zone

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Seasonal and spatial patterns of plankton communities and copepod egg production were investigated and related to environmental conditions in the Guadiana river estuary system. Mesozooplankton and phytoplankton samples were collected monthly at two sampling stations, located in the inner part of the river estuary (St1) and at the adjacent coastal area (St2), from December 2008 until June 2010. Mesozooplankton composition varied between the two sations mostly due to the freshwater flow variability that influences the zooplankton diversity and composition of St1. Special attention was given to the genera *Acartia* which was dominant during the sampling period. Variations in population structure, egg production rates (EPR) and hatching success (HS) of this *taxa* were analysed in relation to environmental parameters (temperature, salinity, chlorophyll and freshwater discharges). Additionally, the RNA:DNA ratio of the same females used in the EPR experiments were analysed to find their relationship with the reproductive traits measured (EPR and HS). EPR was higher during spring with a maximum value of 27±3.7 eggs female^{-1} day^{-1} and lower during winter. EPR results for St1 related positively with chlorophyll concentration while there was not a significant correlation with temperature and salinity. Higher values of EPR were found in 2010 when compared with 2009, which could be explained by the extremely high amount of freshwater discharge during 2010 winter months (January to March) that increased the input of nutrients which favor planktonic productivity.

March 17, 12:10 (S5-6878)

Effect of summer eutrophication on the coastal zooplankton community composition along the Iberian Alborán Sea (SW Mediterranean)

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Eutrophication occurs when an excess in the rate of supply of organic matter exceeds the buffering capacity of the ecosystem. Consequently, the ecosystem begins to change in terms of its ecological structure and function. The hydrography of the Alborán Sea is very dynamic; depending on the strength of the currents and the direction of the wind, the surface coastal water masses could be of either Atlantic or Mediterranean origin. In addition, the Iberian coast has many river discharges, estuaries and semi-closed bays, which are likely to be affected by eutrophication. Moreover, during summer, the coastal population increases 3- to 6-fold due to tourism. Within the framework of the "eutrophication monitoring strategy" of MEDPOL (Programme for the Assessment and Control of Pollution in the Mediterranean region), we conducted a monitoring cruise during July 2010 along the Iberian Alborán coast, from Algeciras to Cartagena, to investigate the levels and sources of eutrophication and to assess its possible effects on the coastal zooplankton community. Physical variables, pH, dissolved oxygen, nutrients and chlorophyll analyses were used to identify several hotspots, which differed in terms of zooplankton abundance and taxonomic composition of the dominant groups.

S7 Oral Presentations

March 17, 8:35 (S7-7073), Invited

The physiology, bioenergetics, and life history traits of *Calanus* species in Arctic and Subarctic seas

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Copepods of the genus *Calanus* are important members of the mesozooplankton communities in Arctic and Subarctic seas. Because they so often dominate the biomass, they are significant consumers of the microbial food web, recyclers of nutrients, transformers of particulate organic matter, and controllers of the direction and flow of energy in these marine ecosystems. I will compare and contrast the biology, focusing on physiology, bioenergetics and life histories, of the different *Calanus* species inhabiting these high-latitude seas. I will show how the observed distributions of the different species compare with predicted distributions based on their biology, and discuss where further work is needed to help us better understand the differences between observed and predicted distributions of *Calanus*. I will speculate on how climate change, including warming, reduction in ice coverage, and changing seasonality, might impact the distributions of these species in the future and how these changes may alter the structure and function of theses high-latitude marine ecosystems.

March 17, 9:00 (S7-6935)

Does fit mean productive?

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The condition factor (CF), defined originally as the ratio of the body weight to the cube of the cephalothoracic length, has been suggested as a valuable indicator revealing the influence of food or other environmental factors on the physiological condition of copepods. We present here a unique dataset of seasonal variations of the CF of adult females of three copepod species, *Calanus helgolandicus, Centropages typicus* and *Temora longicornis*. Secondary production, as well as egg hatching success and egg diameter, were also monitored and related to the environmental food conditions. Samples were collected weekly from the station L4, in the western English Channel, from November 2004 to January 2006. Population dynamics of the three species were also followed. While environmental parameters explain much of the variance observed in morphometric measurements, a high range of variance was observed in the condition factor for the three species. Within each species, the CF was positively and significantly correlated with egg production rates, suggesting that the CF could provide an 'instantaneous' index of physiological activity of field populations. However, when comparing the CF-egg production relationship among groups, species with a higher CF (*e.g. Calanus helgolandicus*) tend to be much less productive than species with a lower CF (*e.g. Centropages typicus*). We suggest that the CF is certainly a meaningful index, but should be interpreted in the context of copepod life-cycle strategies.

March 17, 09:20 (S7-7224)

Effects of temperature and oxygen on metabolic parameters for eucalanoid copepods of the eastern tropical north Pacific: Implications for biogeochemical cycles

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The eastern tropical north Pacific is a region characterized by a severe oxygen minimum zone. Numerous copepods of the family Eucalanidae inhabit this area and show distinct vertical distributions, likely related to the oxygen environment. In this study, oxygen consumption, urea, ammonia and phosphate excretion rates were measured for four species of eucalanoid copepods: *Subeucalanus subtenuis*, *S. pileatus*, *Rhincalanus rostrifrons* and *Eucalanus inermis*. Rates were assessed at three temperatures (10, 17 and 23ºC) and two levels of oxygen (15 and 100% air saturation) using end point experiments. Temperature and species were the two most important factors in predicting metabolic rates. Except for urea, all rates tended to increase with temperature. *E. inermis* had the lowest weight-specific metabolic rates, while *S. subtenuis* and *S. pileatus* had the highest. *R. rostrifrons* appeared to be intermediate. Body turnover rates for nitrogen and phosphorus were similar between species, despite differences in weight-specific rates. Decreased oxygen consumption rates at low oxygen concentrations were observed for *S. subtenuis* at 17ºC, suggesting oxygen limitation under such conditions. Urea excretion rates illustrated an interaction between temperature and oxygen concentrations. A positive relationship was found between urea excretion rates and oxygen concentrations at high temperatures, while a negative relationship was observed at low temperatures. Knowledge of such differences is important for accurate modeling of the role of zooplankton in biogeochemical cycles. It is particularly necessary to understand how oxygen levels influence these rates, as oxygen concentrations are decreasing in our oceans and oxygen minimum zones appear to be expanding.

March 17, 09:40 (S7-7276)

Health condition and body growth rates of euphausiids of the California and Humboldt Current Systems and the Gulf of California using the hepato-somatic index

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We evaluated the relative size of the hepatopancreas (HP) in relation to the cephalothorax length (as a hepato-somatic index, HSI) and its association with instantaneous growth rate (IGR) from five euphausiids species: *Euphausia pacifica* and *Thysanoessa spinifera* collected off Oregon, USA in August-September 2010, *Nyctiphanes simplex* and *Nematoscelis difficilis* collected in the Gulf of California, Mexico in March and October 2010, and *Euphausia mucronata* collected off Antofagasta and Concepcion, Chile in Autumn/Spring/Summer 2010. Previous studies using this method have focused on Antarctic krill species. Euphausiids had significantly higher HSI in spring-summer when coastal upwelling promotes more favorable conditions for feeding. HPs with opaque and bright coloration were associated with poor/famine and healthy/well-fed conditions, respectively. Krill incubations showed that changes in the HSI are strongly associated with the food concentration and that they responded relatively fast (days) to changes in trophic conditions. Total length-HP regressions allowed us to identify a similar pattern for all krill species studied even though they inhabit different latitudes and ecosystems. Due to variability in HP shape, we propose to estimate the area of the HP and cephalothorax rather than measure only the longest axis of the HP, as in previous studies. We suggest that the study of the change of the HSI is a useful indicator of physiological condition at both the individual and population levels and can be utilized in regions with high environmental variability (temperate and subtropical regions) in addition to polar ecosystems.

March 17, 10:30 (S7-7143)

Krill physiological condition and growth in relation to changing environmental conditions in the Northern California Current, USA (2007-2010): *Euphausia pacifica* and *Thysanoessa spinifera*

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Krill condition was measured in terms of length-weight relationships, carbon content, and the size of the hepatopancreas, or digestive gland, relative to carapace length. These measures of krill condition can reflect the environmental variability and food availability. Length-weight and carbon content are a measure of feeding conditions during the previous month or two whereas the digestive gland size in individual animals can be used to measure the recent or localized feeding conditions at the time of capture. Over the course of a year, growth is related to feeding events and seasonal chlorophyll *a* concentrations, and individual animals can shrink or grow based on food availability. Based on the PDO (Pacific Decadal Oscillation), 2007 was a warm year in our study area, 2008 a cool one, and 2009-2010 an El Niño. We will use seasonal length, weight, and carbon analysis as well as the hepatopancreas condition to look at the changing environmental conditions between these three contrasting years and how this affects krill fitness. We also compare the Northern, Central, and Southern regions within the Northern California current.

March 17, 10:50 (S7-7324)

Effect of spring diatom bloom on reproductive activity, egg production and hatching success of *Eucalanus bungii* in the Oyashio region, western subarctic Pacific

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Eucalanus bungii is known to spawn at the surface during spring after winter diapause at depth. We investigated the effect of a diatom bloom on their reproductive processes. In spring *E. bungii* rapidly ascended to the surface in response to Chl-*a* increase (>1 ug/L). After surface emergence females accumulated lipid storage with concurrent feeding on diatoms, and commenced egg production after their lipid storage sac reached 3.8% (in diameter) of the prosome length. The egg production rate was related to lipid storage rather than ambient Chl-*a*. Egg hatching success varied from 0 to 90%, depending on the sampling station. Three types for hatching failure were identified: 1) abnormal eggs with a broken membrane, 2) unhatched eggs which looked normal but did not hatch after predicted period of hatching, and 3) deformed nauplii which died eventually after hatching. Occurrences of the abnormal eggs and unhatched eggs were negatively associated with the total amount of phospholipids in eggs and with the n-3PUFA within triacylglycerols in maternal lipid storage. Phospholipids and n-3PUFA seemed to be obtained from the diatom diet, though the accumulated maternal lipid contents did not show significant relationships with the concurrent feeding rates on diatoms. Although lipid class and fatty acid composition showed no relationship with the occurrence of deformed nauplii, the deformed nauplii were positively related with the total ingestion on diatoms, suggesting the deleterious effects by diatoms. These results indicate that commencement of reproduction in *E. bungii* is dependent on the timing of the spring bloom, and grazing on diatoms is essential for lipid accumulation and hence their egg production and hatching success. However, excess feeding on diatoms could result in minor losses in recruitment due to deformed nauplii.

March 17, 11:10 (S7-7212)

A unifying theory of metabolic scaling and life history evolution for developmental time

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The Metabolic Theory of Ecology states that metabolic rate, mainly controlled by individual mass and temperature, determines many other biological rates and times. This statement contrasts with Life History Optimization theories, where life history traits are shaped (optimized) by evolutionary processes. Despite copious support for both theories, we lack a unifying model that considers both perspectives simultaneously. In this work, we provide the basis for such a unified theory, linking the Ontogenetic Growth Model of West et al. and the Smith-Fretwell model for optimal number of offspring. We show that the embryo developmental time is the result of both maternal investment in offspring and the metabolic constraints on offspring growth. The model predicts a shorter developmental time in organisms producing larger number of offspring.

March 17, 11:30 (S7-7332)

Functional response of carbon absorption efficiency in the calanoid copepod *Acartia tonsa*

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We constructed a general relationship between prey concentration and absorption efficiency (AE; previously termed assimilation efficiency) in the cosmopolitan calanoid copepod *Acartia tonsa*. The relationships between observed AEs and prey concentrations differed between prey species. While AEs decreased asymptotically with prey concentration on the cryptophyte *Rhodomonas baltica*, the chlorophyte *Dunaliella tertiolecta* generated a v-shaped response, whereas AEs remained constant on the diatom *Thalassiosira weissflogii.* We used these observations to develop a mechanistic gut model in which gut carbon concentrations depend on ingestion rate and either egestion rate or absorption rate. To investigate which rates were more important for AE, two different model modes were run: absorption was set to vary according to absorptive enzyme kinetics and egestion set to relate linearly to gut carbon concentration, or the contrary, egestion was set to vary according to enzyme kinetics and absorption set to relate linearly to gut concentration. This approach revealed that copepod carbon AE is controlled primarily by egestion rate kinetics and is independent of absorptive enzyme kinetics. Accordingly, we suggest a simplified regression model for the functional response of AE in pelagic copepods based solely on rates of ingestion and egestion.

March 17, 11:50 (S7-7316)

Oxidative stress and antioxidant responses in copepods: Effects of food quantity and quality

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Evidence is accumulating that many physiological disorders are related to the imbalance between pro-oxidant and anti-oxidant homeostatic cellular conditions, *i.e.* oxidative stress. The metabolic costs for antioxidant defenses link oxidative stress to higher-level responses, as any increase in investment in the antioxidant system can only come at a cost of an investment elsewhere, *e.g.*, it may facilitate senescence and shorten life-span, decrease food intake, growth and reproductive output. We tested a hypothesis that excessive food intake and inadequate food may influence the antioxidant capacity of zooplankton grazers. This was done by studying antioxidant levels (SOD, CAT, GST, astaxanthin), oxidative damage (lipid peroxidation), feeding and reproduction in the Baltic copepods *Acartia bifilosa* and *Eurytemora affinis*. The experiments were conducted to assay responses of copepods to (1) toxic cyanobacteria and a high quality algal food at varying concentrations, and (2) diets that were manipulated to achieve suboptimal stoichiometry and protein content. The observed responses indicate that oxidative damage resulting from saturated feeding rates was more profound than effects of toxic cyanobacteria, whereas effects of stoichiometrically unbalanced food and low protein food were intermediate. These findings may provide a mechanistic link between feeding conditions and copepod growth in eutrophied systems.

March 17, 12:10 (S7-6971)

Productivity of mesozooplankton: Scaling of aspartate transcarbamylase activity (ATC) measurements by allometric model calculations

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There are several options for estimating zooplankton metabolism and growth: time consuming incubations and demographic analysis of zooplankton organisms, time effective biochemical approaches on cellular level, and models, often based on results of the first category. All of them have pros and cons. Biochemical methods allow high sampling frequency. In some cases, results can be directly applied as changes in the amount of metabolic end products. However, there is no scaling factor, no direct calibration, available for enzymatic productivity measurements based on ATC activity. Currently, only an index of relative growth rate in terms of carbamyl aspartate per time is available for this purpose. However, since physiological processes and their controlling enzyme reactions are closely related to body size, allometry-based models may offer a solution. They predict trends from individual biomass measurements. In this study both, results based on calculated body-size dependent growth rates and enzymatic activity based growth measurements will be compared. The individual biomass was determined dividing *in situ* biomass concentration by abundance. We found that calculated biomass specific productivity rates and ATC activity were highly correlated (power function, $p<0.001$). Derived patterns coincided with those of environmental properties.

S8 Oral Presentations

March 18, 8:35 (S8-7318), Invited

Zooplankton and biogeochemical cycles: Who is conducting the orchestra?

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The export of organic matter from surface waters to the deep ocean is a key process in carbon sequestration. This export consists both of a gravitational sinking component and an active transport component carried out by migrant biota (zooplankton and micronekton). These organisms transport carbon to the mesopelagic zone due to their feeding in shallower layers and their defecation, respiration, excretion and mortality at depth. This active transport has usually been considered much smaller than export by gravitational sinking. In subtropical waters epipelagic mesozooplankton biomass increases as the winter mixing develops, but peaks in every full moon and decrease thereafter due to the effect of predation by interzonal diel vertical migrants (DVMs). The consumption and subsequent transport of epipelagic zooplankton by DVMs after every full moon was similar to the mean gravitational export. This effect of light in the ocean produces a cascade downward the food web, promoting changes in the structure of the ecosystem. These top-down effects are suggested to drive energy and matter in the ocean from the recycling loop to large zooplankton and micronekton, enhancing active flux and the efficiency of the biological pump.

March 18, 9:00 (S8-6890)

Physical forcing, zooplankton dynamics and particulate carbon export to the deep ocean in the northwestern Sargasso Sea

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High resolution time series data on 0-200m macrozooplankton abundance and distribution off Bermuda was measured by acoustic backscatter intensity (ABI) using a 153 KHz ADCP mounted on the Bermuda Testbed Mooring (BTM). The ABI signal was compared with concurrent physical measurements collected by other BTM sensors and with concurrent measurements of deep particle flux collected by the Oceanic Flux Program (OFP) time-series sediment trap mooring. The BTM sampled the periphery of a (formerly) productive mode water eddy in May, and the periphery of a strong anticyclonic eddy in September. ABI increased during passage of both eddies, suggesting a significant increase of zooplankton production due to localized upwelling in the high velocity boundary of these eddies. Concurrently, the OFP traps recorded a small increase in fecal pellets and copepod nauplii. The high resolution of our ADCP time series also allowed us to resolve variability in zooplankton diel vertical migration and abundance. The ABI also provided further evidence that zooplankton vertical distribution and diel migration is strongly influenced by the lunar cycle. This lunar modulation of vertical migration may have an important influence on active transport of carbon and nutrients to the deep ocean, as zooplankton migrate deeper in the water column during the full moon, excreting and producing fecal pellets. Our results provide additional evidence that mesoscale eddies play an important role in the ocean's biological pump by promoting primary and secondary production which, in turn, can enhance particulate carbon export to the deep ocean.

March 18, 9:20 (S8-7162)

Hypoxia induced metabolic suppression in migratory zooplankton living in oxygen minimum zones

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Oxygen minimum zones (OMZ) are expansive features characterized by hypoxic water at intermediate depths. Recent evidence suggests that oxygen minimum zones will expand vertically with global climate change, emphasizing the need to study the organisms that regularly encounter these zones. Here we assess the respiratory physiology of zooplankton, including euphausiids, pteropods, copepods, amphipods and squids that perform diel vertical migrations into OMZs. Aerobic and anaerobic energy equivalents were measured to estimate the contribution of each to total energy production in the OMZ. In all species tested, oxygen consumption was lower under conditions equivalent to those experienced during daytime forays into the OMZ. Anaerobic metabolism contributes to energy production but does not compensate entirely for the reduced rate of aerobic metabolism. For example, Eastern Tropical Pacific euphausiids held for 5 hours under hypoxic conditions (<40µM) showed a 5-fold elevation in lactate values and a 3-fold reduction in oxygen consumption rates compared to specimens held for the same duration under normoxic conditions. This amounts to a 50% reduction in ATP production at low oxygen concentrations. Furthermore, we identify a threshold oxygen level at ~0.15µM below which further adaptation for oxygen extraction is limited. In regions with oxygen below this level, few species remain at depth during the nighttime and metabolic suppression (50-80%) is the dominant physiological strategy. Consequently, metabolic suppression effectively reduces the contribution of zooplankton to the vertical carbon flux as the rate of CO_2 production is reduced in proportion to oxygen consumption.

March 18, 9:40 (S8-6992)

Mesozooplankton demands exceed carbon flux in the twilight zone

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Downward fluxes of particulate organic carbon (POC) through the 'twilight zone' (upper 100–1000m) are attenuated by abiotic and biotic processes. The latter includes activities such as the repackaging and remineralization of POC by bacteria, zooplankton and other heterotrophic organisms. Mesozooplankton are a key player in regulating the carbon export efficiency; their faecal pellet production, feeding, respiration and vertical migrations all impact upon the downward flux of POC. Resident mesozooplankton in the twilight zone are hypothesised to satisfy their metabolic demands by feeding directly or indirectly (via feeding on microzooplankton and faecal pellets) on the POC flux. We compared copepod carbon demands during night and day with POC flux attenuation at two sites overlying the Porcupine Abyssal Plain (PAP), Northeast Atlantic, in summer 2009. Vertical profiles of mesozooplankton biomass, sampled in 40 m depth intervals from 0–1000m, were converted into carbon demand using well-established allometric equations. POC flux attenuation between 200–600m was measured using neutrally buoyant sediment traps. Integrated copepod carbon demand between 200–600m exceeded the carbon flux attenuation by more than an order of magnitude, indicating that copepods could not have satisfied their metabolic requirements by feeding in this habitat alone. We thus propose that the majority of copepods found in the twilight zone do not feed there, owing to the poor energetic- and nutritional content of the available POC.

March 18, 10:30 (S8-7019)

Copepods and the biological pump: The potential effects of large *vs.* small copepods on vertical flux

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Large, suspension-feeding calanoid copepods and small, particle-colonizing copepods can both influence the magnitude of downward particle transport, although by different mechanisms. We hypothesized that large copepods, such as *Calanus finmarchicus*, would ingest sinking particles whole at one depth, and egest part of the ingested material at another depth. Small, particle-colonizing species, such as *Microsetella norvegica*, would in turn colonize and reside on sinking particles, ingesting only parts of them. To compare the potential effects of these two groups on vertical flux, we combined field sampling on zooplankton vertical distribution, pellet production, and gut evacuation time in SW Greenland, with laboratory experiments on functional responses of feeding on different types and sizes of aggregates. The laboratory results show large differences in functional responses depending on aggregate type (appendicularian house, diatom or cyanobacteria aggregate) rather than size, suggesting that both colonization and ingestion of aggregates are influenced by the origin of the aggregate. Further, *M. norvegica* and *Oncaea* sp. appear to have low weight-specific feeding rates on aggregates, ranging from insignificant consumption of fecal pellets to a maximum of ca 0.5 µg C (µg C)$^{-1}$ d^{-1} on appendicularian houses. This suggests that small particle-colonizing species only will have a substantial effect on particle flux at extremely high densities, while *C. finmarchicus* could have a higher impact due to its high and diurnally changing pellet production rate and tendency to perform vertical migration.

March 18, 10:50 (S8-7215)

Degradation of copepod faecal pellets: The role of small-sized, <180µm, plankton and *Calanus finmarchicus*

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Copepod faecal pellets (FP) are considered important contributors to vertical carbon flux, but investigations comparing FP production with FP export from sediment traps conclude that this is rarely the case. FP are to a large extent degraded and even among large, fast sinking FP, only a fraction reach sediment traps. Retention mechanisms for copepod FP are still not well understood. In order to investigate the retention potential of the small, <180µm, compartment of the plankton community, we incubated FP produced by *Calanus finmarchicus* in 180µm filtered water from Chlorophyll *a* max. From a series of experiments we found that the degradation of large FP is time-dependent, as no degradation was apparent after 20 or 48 h incubation, but after 72h FP volume was reduced by 25%. We further found that large filter-feeding copepods may act as a catalyst on the degradation process, since FP degradation increased from 0 to 75% after 48h incubation with 5 *C. finmarchicus*. Bacterial growth was similar in control and treatment bottles, and thus not considered important for FP degradation rates in our experiments. We conclude that ciliates and dinoflagellates are able to degrade large copepod FP but this requires time. Rather than looking for single-factor explanations trying to understand flux-regulating processes, it is important to investigate combined effects to approach the complexity of carbon flux regulation in natural systems.

March 18, 11:10 (S8-6952)

Marine snow originating from appendicularia: Age-changes in houses settling characteristics and the effect of ballast material

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The evolution of size, sinking velocity, and mass of aging discarded appendicularian houses, a component of marine snow, were examined in laboratory experiments. The sizes of discarded houses decreased over time, with a rapid deflation during the first hour, followed by a slower rate of compression leading to a significant decrease in diameter. The initial rapid deflation of the houses is accompanied by a massive loss of particles and loss in weight. The initial mass loss is left as a trail of elevated particle and solute concentration in the wake of the sinking aggregate. Subsequently the house mass decreases at a much lower rate than is consistent with bacterial degradation. The combined effect of mass losses and of the deflation-compression process is an increase in the sinking speed of the houses. The observed deflation-compression process may have several consequences for the dynamics of appendicularian-derived marine snow aggregates including increase of marine snow sinking rates with depth and influencing degradation processes by detrivorous organisms. In a second study, we investigated the effect of the inclusion of various ballast materials on the sinking speed of discarded houses and faecal pellets. Whereas ballast material does not seem to induce strong changes in faecal pellet sinking rate, coccolithophores and Saharan dust significantly increase (up to 5 times) the sinking speed of discarded houses. These results have important implications for our understanding of carbon fluxes originating from appendicularians.

March 18, 11:30 (S8-6949)

Geochemical biogeography: Bridging the gap between zooplanktology and biogeochemistry

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Zooplankton have an important influence on regional and global biogeochemical cycles, however most biogeochemical models represent zooplankton in only the simplest way. The biogeography of key zooplankton species can control the strength and efficiency of the biological pump. For example, dissolved and particulate carbon export by active transport driven by vertically migrating zooplankton is often comparable to the passive sinking of particulate organic matter (POM), and detritivorous species influence vertical attenuation of sinking POM and its remineralization with depth. Although we have a long history studying zooplankton epipelagic distribution, our understanding of the biogeography of some key zooplankton taxa is still limited, especially the detritivorous and gelatinous zooplankton, and also most mesopelagic species. Information from studies on geochemical biogeography, *i.e.*, the biogeography of key species influencing biogeochemical cycles, and studies on their biogeochemical function, is useful to understand the role of zooplankton in biogeochemical cycles and to forecast the future under global warming. Geochemical biogeography is also essential for designing regional models which can then be compared to highlight the regional variability in biogeochemical cycles characterized by zooplankton. Further studies on geochemical biogeography of zooplankton will bridge the gap between zooplanktology and biogeochemistry.

March 18, 11:50 (S8-7226)

Zooplankton mediation of carbon cycling and export in the Amundsen Gulf system (southeastern Beaufort Sea)

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Arctic mesozooplankton assemblages fulfill key functions in the energy transfer through the marine food web and in the biogeochemical processes within the ecosystem. Because zooplankton will be strongly affected by Arctic Ocean rapid warming, better understanding of their dynamics and role in the biological carbon pump is needed. During the CFL mission in the Beaufort Sea from October 2007 to July 2008, we examined vertical distribution of biomass and metabolic rates by means of ETS essays on two mesozooplankton size classes at 44 stations in the Amundsen Gulf. In autumn, large zooplankton (>1000µm) were distributed closer to the seafloor than small zooplankton (200-1000µm), until they migrated to the 0-60m layer in early May when pelagic primary production started. Large zooplankton carbon release was 5-fold and 10-fold greater than the mean annual POC flux measured by sediment traps at 100m and 200m depth, respectively, while small zooplankton respiration was 2-fold and 3-fold greater. However, small zooplankton contributed more to carbon remineralisation than large organisms in the surface layer in autumn. Due to their substantial contribution to carbon remineralisation and different seasonal vertical migration patterns and feeding modes, a likely shift in Arctic zooplankton size, triggered by climate warming, will lead to the disruption of the biological pump. The system may probably experience an increase in surface carbon cycling by small omnivores and detritivores at the expense of active respiratory flux at depth mediated by large herbivore seasonal migrant copepods.

March 18, 12:10 (S8-7311)

The impact of upwelling filaments on carbon cycling and advection of coastal zooplankton: A synthesis with new observations

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Upwelling filaments play an important role in the seaward transport of organisms, nutrients, and water properties from productive continental shelf areas to relatively oligotrophic ocean regions of all the eastern boundary upwelling ecosystems. Yet the biological impacts of only a few upwelling filaments have been studied, and even fewer studies have reported the seaward volume and carbon transport of those filaments. In this study, we add to ongoing investigations of how mesoscale circulation impacts the cross-shelf exchange of carbon, here focusing on the role of zooplankton transport within the circulation features. We present new observations of the volume transport, zooplankton species and biomass distributions, and horizontal carbon transport in a California Current upwelling filament. We compare these observations to previous reports from upwelling regions around the world to estimate the relative importance of filaments to cross-shore transport in each system.

Our new observations include CTD profiles, ADCP velocity measurements, and mesozooplankton collections across a deep (>500m), strong (>40cm/s) upwelling filament that developed off Cape Mendocino, California in summer 2006. Consistent with other studies, we found that abundances of coastal zooplankton with cold-water affiliations were elevated at offshore stations within the upwelling filament relative to surrounding waters, whereas oceanic, warm-water taxa were relatively less abundant within the filament. We estimated transport of >3.6 Sv and >500 metric tons of mesozooplankton carbon moved seaward within the filament each day, creating offshore hot-spots of biomass and production, but potentially resulting in significant losses to shelf populations.

S9 Oral Presentations

March 18, 8:35 (S9-7152), Invited

Species rarity in mangrove coastal lagoons: Timing of spawning, larval transport and settlement

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Our studies on larval transport highlight the role of tidal salinity fronts, local topography, and timing of spawning and settlement in maintaining rare populations of sessile invertebrates.

Mangrove forests grow along the shore in Bahia Honda, a bay in western Panama. Mangrove branches and prop roots are the only substrate available for colonization of intertidal sessile taxa, and surveys in Bahia Honda revealed moderate densities of several sessile species in high salinity coastal lagoons within the bay, but an absence within an estuarine coastal lagoon (Managua). Managua experiences large salinity fluctuations, with alternating rainy and dry seasons, as well as spring-neap tidal variability, and our studies suggest that the large environmental fluctuations explain population's paucity. However, an isolated barnacle *Microeuraphia sp.* population persists upstream in Managua, in a secondary estuarine channel. Tidal currents and salinity structure were measured simultaneously with sampling of barnacle larvae. Managua varied from a highly-stratified salt-wedge to a vertically well-mixed estuary over the spring-neap cycle. Larval samples suggest upstream transport from the bay is associated with tidal intrusion of the salt front, peaking during spring tides. Moreover, during the dry season, localized channel curvature traps salt water, suggesting a mechanism for larval retention near the isolated population. The high-intertidal barnacle *Microeuraphia* can only reproduce and settle around the spring tides, and preliminary results suggest a short larval duration that would minimize larval loss during dispersal. Thus, we speculate that timing of spawning, larval transport and complex local topography explain the persistence of a rare population.

March 18, 9:00 (S9-7081)

Effects of nearshore hypoxia on invertebrate meroplankton of the Oregon coast

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The incidence of ocean hypoxia is increasing in coastal regions worldwide with detrimental effects reported in many species. In the Pacific Northwest, an unprecedented rise of seasonal hypoxic and anoxic events has resulted in mass mortalities of fish and benthic invertebrates. However, the effects of hypoxic events on the planktonic stages, including larvae, are not well understood. We have conducted both laboratory studies and field observations to explore the effects of these hypoxic events on invertebrate meroplankton members.In controlled laboratory experiments, we investigated the mortality of planktonic larval invertebrates exposed to low oxygen conditions. Hypoxic conditions were generated by bubbling seawater with nitrogen gas. Experiments tested the effect of normal oxygen levels and three low oxygen conditions, representative of dissolved oxygen concentrations in the nearshore environment of the Oregon coast, on larval survival. Results revealed a wide range of tolerances, from species with little tolerance to hypoxia (*e.g.* the shore crab *Hemigrapsus oregonensis*) to species with high tolerance (*e.g.* the Giant green anemone *Anthopleura xanthogrammica*, the California mussel *Mytilus californianus*, and the Ochre sea star *Pisaster ochraceus*). Through field observations, we have explored the nearshore water column distributions of invertebrate meroplankton in relation to dissolved oxygen levels. A Multi Plankton Sampler (HYDRO BIOS MultiNet) was utilized to collect depth stratified plankton samples in nearshore waters of the Oregon coast. Insights gained from both field and laboratory studies will help inform potential future scenarios of marine invertebrate rocky intertidal and benthic community dynamics in settings of increased seasonal nearshore hypoxia.

March 18, 9:20 (S9-6943)

Quantifying mesoscale patterns of spatiotemporal variability of four temperate larval fish species on Canada's west coast

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As part of the Canadian Healthy Oceans Network (CHONe), we are examining the ichthyoplankton population connectivity in the Strait of Georgia (British Columbia, Canada). It is critical to understand the regional source-sink dynamics and the underlying dispersal patterns of fish species inhabiting the Strait during their planktonic larval phase for the application of marine protected areas in this area. We examined previously unanalyzed ichthyoplankton data from 1979 to 1981 and our recent data collected in 2009 and 2010. By using spatial analysis and GIS approach, we mapped the historical and recent larval distribution of four commercially valuable fish species (*Clupea pallasi, Merluccius productus, Theragra chalcogramma and Sebastes sp.*) in the Strait. Our goal was to look for evidence of consistent spatial patterns across years for each species (*e.g.* sources and sinks, hotspots) and to explore species-specific dispersal pathways by comparing patterns of spatiotemporal variability. Preliminary analyses suggest that the spatial distribution of larval abundance is quite variable among the four species, but largely consistent across years for each species. Local oceanographic phenomena and early life history characteristics likely play important roles in the patterns of larval dispersal. Results from the recent surveys will ultimately be seeded into a regional 3D circulation model (ROMS) to determine whether there exist predictable source-sink ichthyoplankton transport corridors in the Strait.

March 18, 9:40 (S9-6959)

Meat and two veg? Determining feeding selectivity of bivalve larvae in the Western English Channel with traditional and molecular techniques

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Meroplankton, including bivalve larvae, are an important and yet under-studied component of coastal marine food webs. During the reproductive season bivalves may produce large numbers of transient pelagic planktotrophic larvae that are the sole dispersal vector for sessile invertebrates. While in the surface waters, larvae compete with holoplanktonic grazers and are a source of prey for a variety of organisms. Food availability plays a critical role in allowing the larvae to gain sufficient energy and nutrients for metamorphosis and development, in turn affecting the number of recruits returning to the seafloor.

Our study looks at the temporal distribution of bivalve larvae over a 20-year period as part of the Western Channel Observatory time series programme. Over an annual cycle we have conducted a series of experiments to determine larval feeding selectivity and rates in natural sea water. Complementary gut content analysis was performed using a PCR-based method for detecting prey DNA on both animals from the laboratory and the field. Molecular techniques have also been used to enhance our resolution of species identification.

Bivalve larvae were shown to be omnivorous, typically feeding on smaller sized prey with the highest ingestion rates for pico- and nanoeukaryotes, but with ciliates also contributing to the total carbon consumed daily. This is a unique study in that it characterises *in situ* feeding rates on natural assemblages of bivalve larvae together with temporal distribution in coastal waters of the English Channel, providing an increased understanding of the role meroplankton play in the pelagic environment.

March 18, 10:30 (S9-7257)

Intertidal population connectivity: The role of larval supply

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In marine systems, connective processes are mainly constrained to the planktonic larval stages, as most benthic species are sedentary as adults. Though larval connectivity has been identified as a driving force in the establishment and maintenance of marine populations, the factors controlling the magnitude and extent of connectivity are not well defined. Physical transport is a contributor, but other factors, including larval supply, must also be investigated.

Populations of the barnacle *Semimalanus balanoides* in the United Kingdom provide an ideal system for testing the role of larval supply, as larval recruitment of this species exhibits a strong negative correlation with temperatures between 2 and 8ºC. The recent extreme European winters provide us with a range of relevant temperatures and corresponding larval abundances.

In 2010, we quantified *S. balanoides* in Southwest England, an area where this species has been uncommon in recent decades. We predicted that larval supply would increase dramatically in response to the recent extreme winters, and is subsequently responsible for the species' expansion in Southwest England. Specifically: 1) *Semibalanus balanoides* abundance at the L4 plankton station (offshore of Plymouth, England) will be inversely related to temperature. We tested this hypothesis by comparing quantitative larval surveys at L4 to water temperature. 2) Cold winters will have allowed increased recruitment in Southwest England. We tested this hypothesis by quantifying larval settlement in Southwest England after the cold winters of '08-'09 and '09-'10. Prior to 2008, *S. balanoides* adults were uncommon in Southwest England, but abundant recruitment occurred in both cold years.

March 18, 10:50 (S9-7006)

Nearshore larval retention among years and between regions of varying upwelling intensity

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The ability of miniscule larvae to control their fate and replenish populations in dynamic marine environments has been a long-running topic of debate of central importance for managing resources and understanding the ecology and evolution of life in the sea. In upwelling regions, larvae are considered to be highly susceptible to offshore transport that increases dispersal, limits onshore recruitment, and reduces the intensity of community interactions. We examined the cross-shelf distribution of larval crustaceans at two stations located 1 and 5 miles from shore off central Oregon, USA for eight years in a region characterized by intermittent upwelling and high recruitment. These years exhibited differences in oceanographic forcing including the phase of the Pacific Decadal Oscillation (PDO), upwelling intensity and the timing of the spring transition. We show that most species of crustaceans are retained nearshore across years regardless of changing oceanographic conditions. In contrast, *Emerita analoga*, is present only during years when the PDO is in the positive phase. There is also a positive relationship between the presence of this species and the timing of the spring transition, suggesting that larvae are transported into our study area from southern locales. Finally, we compare the cross-shelf patterns in this region of intermittent upwelling to those observed off northern California, USA, a location characterized by strong upwelling and recruitment limitation.

March 18, 11:10 (S9-7118)

Assessing swimming behavior and velocities of barnacle larvae in a downwelling flume

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It has been proposed that barnacle larvae could maintain their position in shoreward-propagating fronts by swimming upward against downwelling flow, potentially mediating onshore transport of larvae towards intertidal populations. This study developed a novel flume to characterize swimming behavior of barnacle cyprids in laboratory-generated downwelling flow. Seawater was pumped through a cylindrical observation chamber fitted with diffusers to produce a homogeneous downwelling velocity field. The flume generated plug flow with mean downwelling velocities of 0 to -47.3 mm s^{-1}. Behavior experiments were done with field-sampled *Semibalanus balanoides* cyprids. Vertical swimming rates and behaviours were estimated from video observations, and a mixture model was used to estimate velocity distributions for distinct behavioral modes. Larvae exhibited multiple behaviors but typically swam upward in response to downwelling, with a maximum estimated vertical velocity of 72.3 mm s^{-1}. When faced with strong downwelling flows, cyprids alternated between upward swimming and sinking or hovering to help maintain their vertical position in the chamber. As downwelling velocities increased, the proportion of cyprids capable of depth-keeping decreased and larvae tended towards sinking rather than swimming or hovering. This study supports earlier hypotheses based on field observations by demonstrating that *S. balanoides* cyprids swim well enough to counter downwelling velocities characteristic of convergence zones. Swimming against downwelling flow could be an adaptive behaviour that enables shoreward transport in the absence of any larval ability to swim toward shore or even to sense its direction.

March 18, 11:30 (S9-7269)

Interannual and intraseasonal variability in dispersion of oyster larvae: A numerical study coupling an Individual-Based model to a hydrodynamic model.

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Individual-Based Models (IBM) can be used to study dispersal of freely drifting marine organisms, such as larvae, which are affected by growth and behaviour. These physiological processes are controlled by environmental conditions (*e.g.*, temperature, salinity, *etc.*) which can be estimated from hydrodynamic models. For this study we converted the particle-tracking module in the ROMS code into an IBM representing growth and vertical migration of eastern oyster larvae. ROMS was configured for Delaware Bay to calculate the estuarine circulation in response to tides, winds and river discharge. Larvae were released from a number of reefs at several times and tracked until they reached a competent settlement size. The results show that variations in temperature and salinity have a large impact in the survival and dispersal of larvae. Low survival is associated with areas having low salinity or low temperature. Interannual and intraseasonal fluctuations in survival are related with drops in salinity caused by an increase in river discharge. River discharge also affects dispersal pattern, causing a shift between middle- and lower-bay settlement. Larvae released from upper-bay reefs during spring or neap tide are transported mostly up-estuary, where they are exposed to lower salinities that lower their chance of survival. Our results confirm that both physical and biological processes influence the patterns of larval dispersal and recruitment over Delaware Bay. Finally the modification of ROMS drifters into an IBM provides a new tool for studies of larval dispersion and other individual-based studies.

March 18, 11:50 (S9-7292)

Modelling the influence of adult distribution, size-dependent fecundity and larval mortality on the dispersal of sea scallop (*Placopecten magellanicus*) larvae

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For benthic species with a planktonic phase of development, larval dispersal and supply are key factors in estimating larval connectivity and metapopulation dynamics. Predicting supply requires knowledge of the seasonal timing, source location, and abundance of larvae spawned in addition to planktonic transport processes. While previous work characterizing larval exchange among sea scallop (*P. magellanicus*) beds on Georges Bank has focused on larval dispersal, the spatial distribution of adults and resultant larval production may be as important in determining connectivity among beds. Here we examine the importance of the spatial distribution of adults by comparing larval connectivity estimates to previous work that assumed uniform larval distributions at spawning. The effect is examined for different spawning seasons (spring and fall) and eras in the fishery (before and after the implementation of fishery closed areas). These simulations couple a model of larval production and mortality with a 3D particle-tracking model to estimate the spatial distribution of a cohort of larvae at settlement. Preliminary results suggest the need to consider the distribution of adults and also provide insight into other important questions, such as the relative importance of spring-spawned larvae in determining connectivity. We discuss the importance of these effects relative to other sources of uncertainty, namely physics and larval behaviour, when estimating larval connectivity to provide useful guidance for scientific sampling programs and fisheries managers.

March 18, 12:10 (S9-7314)

Daily larval availability and settlement of *Tetraclita stalactifera* (Cirripedia) at Cabo Frio, Brazil: Effect of tidal and upwelling transport

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The relationship between the availability of marine invertebrate larvae and benthic settlement/recruitment on rocky shores has been a provocative question in marine ecology. From the knowledge of the spatio-temporal plankton variability, we now apply the same rules to larvae of benthic invertebrates and their own distribution. Thus, we relate variations in the systems of winds, tides, day-night cycles, fluctuations in upwelling and physicochemical characteristics of water as factors that influence the distribution of larvae and, consequently, the processes of settlement/recruitment and community structure. Cabo Frio is an important region in the Brazilian coast that represents the transition between tropical and sub-tropical zones, besides the occurrence of coastal upwelling. In this region, the dynamics of many species, such as echinoderms, crustaceans and algae are influenced by this phenomenon. Previous studies have shown that the occurrence of upwelling is strongly related to reproduction, larval availability and recruitment of *T. stalactifera*. To assess the variability related to the tidal regime (spring or neap tide) and upwelling/subsidence events, daily plankton samples were collected during 150 days between January and May 2000. Our results show a pattern of larval availability related to spring tides as well as subsidence events. The concurrence of these two factors led to the highest larval concentrations and settlement rates. These results help provide a starting point to understand the dynamics of meroplankton in the region, as well as the processes that drive the colonization of substrates by benthic organisms. Further studies on the offshore transport of larvae, the role of internal waves and the diurnal cycle are needed to complement our observations.

Abstracts
Posters

S1 Posters

S1-6897

Effects of long-term climate variability on the mesoplankton community structure in the Black Sea coastal areas

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The combined analysis of the Black Sea historical climate chronology and a long-term dataset of air and surface water temperature, precipitation, wind speed and mesoplankton abundance was performed. In the Black Sea area during the last 2,000 years, about 20 catastrophically severe winters occurred with an average periodicity of about 75-80 years. During the last 100 years, a significant regime shift was noted in the beginning of the last century, and a second occurred in the late 1970s. Similar changes in the ecosystem due to climate-induced regime shifts have been observed in the Baltic Sea and Bering Sea. Rapid reorganizations of the Black Sea ecosystem are often associated with changes in the climate system, affecting plankton production, feeding, migration patterns, growth rates, and mortality of other species and propagating up the food chain. Since 1976, before *Mnemiopsis leidyi* outburst (1989), there were several drastic changes in the habitat conditions for many mesoplankton species, which led to periodic outbreaks of different species of gelatinous organisms. At the same time, some species have undergone large and sometimes sudden population fluctuations. These changes, that previously were described only as the result of the Black Sea eutrophication, human activity or alien species, are caused by the combined impact of all these factors, and including, first of all, long-term climate variability (precipitation, wind speed, river discharge).

S1-6898

Regional differences in water temperature impact on coastal mesoplankton communities

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Based on analysis of the relationships between species ecology and hydrometeorological data in the Black Sea coastal area, it is possible to draw important conclusions about the response of the coastal plankton community to environmental changes. In the present study, the relationship between species abundances and water temperature varied depending on the distance from the coast. It was demonstrated that the coastal areas are most vulnerable to climate change. At stations far from shore, there was a weak dependence of species abundance on water temperature, while close to shore and in bays this relationship increased. For cold-water and eurythermal species there was an inverse dependence on temperature changes of water. For warm-water species, the positive relationship with water temperature increased with proximity to the shore. Spatial variation in these relationships leads to variation in the contribution of taxonomic groups and to differences in responses of the community in coastal and offshore waters.

S1-6910

Seasonal growth, molting and egg production rates of *Nyctiphanes simplex* (Crustacea: Euphausiacea) in the Gulf of California

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The biomass distribution and somatic growth, molting, and eggs production rates were estimated in the Gulf of California during November 2005, January and July 2007 for Nyctiphanes simplex. Biomass and biomass production rates were compared with 12 in situ environmental variables using non-parametric multivariate methods to define the environmental conditions associated with highest biomass production rates. In shipboard incubations N. simplex did not grow, but had instantaneous growth rates (IGR) = 0 or shrank (IGR<0) in all seasons. The proportion of individuals that did not grow was higher in November (23%) and July (22%) than in January (3%), but proportions of individuals that shrank were relatively similar among seasons (21-30%). The N. simplex mean daily total biomass production rate was 0.07 mg DW m^{-3} d^{-1} (standard deviation ± 0.01) and mean annual integrated production was 9.9 mg DW m^{-3} y^{-1} (1.2-18.7 mg DW m^{-3} y^{-1} 95% confidence interval). Somatic growth (46%) contributed with most of N. simplex biomass production, followed by molting (32%), and egg production (22%). Thus, N. simplex invest higher proportion of energy in molting and egg production than previously thought (23 and 2%, respectively). There were regions of high, intermediate and low N. simplex biomass and productivity in all sampling months, which were linked to differences in environmental conditions, but there was no clear seasonal pattern in productivity in any region. This means that the numerous predators that depend on this prey species must dynamically change their distribution pattern seasonally to search and detect the spatially variable centers of N. simplex biomass production in the Gulf of California.

S1-6918

The response of zooplankton body size to warming

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The relationship between body-size and temperature is a classic topic in macro-ecology (Bergmann's rule, James' rule, and temperature-size-rule). The current concern about climate change has led to a renewed interest in size – temperature relationships. In a recent overview of several aquatic studies, Daufresne *et al.* (2009) showed warming-related size declines in bacteria, phytoplankton, zooplankton and fish. Size reduction occurred via three routes: shifts in species, shifts in the age structure within species, and shifts in the size of defined developmental stages. We performed mesocosm experiments, in order to test size-temperature relationships in the context of a semi-natural planktonic food web. The mesocosms (1.4 m^3) were filled with the natural plankton (bacteria, phytoplankton, and heterotrophic protists) from the Baltic Sea at their *in situ* densities. Copepods were added from net catches. The experiments lasted for 29 d. The experimental temperatures were 9.5°, 13.5° (close to *in situ*) and 17.5°C. The experiments provide data, which allow us to quantify the role of species shifts, age structure shifts, and changes in the size of defined developmental stages. The analysis performed so far shows a stronger temporal increase of copepods in the cold and medium treatments than in the cold ones: CV-copepodite *Acartia* were bigger (prosome length) at 9.5° than at 17°C.

S1-6923

Differences on zooplankton productivity in the western and eastern Bering Sea in the "warm" and "cold" periods

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An analysis of the structural and functional characteristics of zooplankton communities and their coupling with oceanographic conditions was carried out for the autumn period in the Bering Sea. The data were collected by research vessels *TINRO*, *Sea Storm* and *Kaiyo maru* in Bering Sea under the international research program BASIS (Bering-Aleutian Salmon International Survey). Based on ice cover extent, 2003 and 2005 were classified as "cold," and 2006 and 2008 were classified as "warm". The species structure of the macrozooplankton community differed significantly between "warm" and "cold" years. In the eastern Bering Sea, zooplankton abundance increased during "cold" years, primarily due to increases in the biomass of large copepods, chaetognaths, euphausiids, and amphipods. Changes in the zooplankton communities in turn influenced production of predatory and non-predatory zooplankton. In cold years in the eastern Bering Sea the production of zooplankton was higher than in the warm period. In the western Bering Sea, changes in species structure and production of zooplankton were not significant between the "warm" and "cold" years.

S1-6924

Composition, distribution and dynamics of large-size jellyfish in the Bering, Okhotsk, and Japan Seas and northwestern Pacific Ocean

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We examined the species composition, horizontal and vertical distribution, vertical migrations, biomass and abundance of large-size jellyfish based on archival data of TINRO-Center from 43 trawl surveys of the epi- and mesopelagic zone of the western Bering Sea, Okhotsk Sea, western Japan Sea, and northwestern Pacific Ocean in 1990-2009. Ten species of Scyphozoa and six species of Hydrozoa occurred in the trawl catches. Jellyfish were widespread and have the highest concentrations in the northwestern Bering Sea, eastern Okhotsk Sea, and Pacific Ocean southward of Commander Islands and eastern Kamchatka. The scyphomedusae *Chrysaora* spp., *Cyanea capillata* and the hydromedusa *Aequorea* spp. dominated the jellyfish biomass. The horizontal distributions of these dominant species showed different patterns. *Aequorea* spp. was concentrated in the deepwater regions. *C. capillata* inhabited mostly shallow regions. *Chrysaora* spp. occurred in all parts of the seas and ocean, but was the most abundant on the shelf. During warm seasons the highest biomass of jellyfish occurred in the surface waters (about 50% in the upper 50-m layer). Jellyfish abundance had two peaks: in the surface layer and in the deep water (700-800 m or deeper). Biomass and abundance of jellyfish increased from spring to fall. During the cold season, the number of jellyfish in the epipelagic layer decreased sharply due to their death after spawning and probably migration of some individuals from the surface to deep water for over-wintering. Biomass and abundance of jellyfish varied greatly from year to year and may change tenfold. The total jellyfish biomass in the western Bering Sea, Okhotsk Sea, western Japan Sea, and northwestern Pacific Ocean may reach 13-15 million tons. Jellyfish dynamics in relation with climate changes in the North Pacific were studied.

S1-6940

Alongshore transport and zooplankton communities in the northern California Current system

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Zooplankton samples were collected biweekly at a coastal station 8km off Newport Oregon U.S.A. from in 1996 until present (2010). Copepods from those samples were identified to species then pooled into one of four categories based on water mass affinities. Warm water species dominate in "warm" years and cold water species in "cool" years. To test the hypothesis that this pattern is due to changes in sub-basin scales advection, alongshore current velocities were estimated from gridded AVISO altimeter data and water level data from NOAA tide gauges (1993–2010). The biomass of cold neritic copepods (*Calanus marshallae, Pseudocalanus mimus and Acartia longiremis*, which are dominants in the eastern Bering Sea and coastal Gulf of Alaska) and the alongshore current exhibit strong seasonal pattern with the biomass of cold neritic copepods fluctuating in opposite phase of the alongshore current: positive alongshore current (northward) corresponding to low biomass in winter and negative alongshore current (southward) corresponding high biomass in summer. Correlation analysis suggested that the biomass of cold neritic copepods decreased with the strength of northward alongshore current. When the Pacific Decadal Oscillation (PDO) is positive, *i.e.* warm conditions, there was more water from south during the winter season. When the PDO is negative, *i.e.*, cold conditions, there were more water from north during the summer season. Transport is likely to be a mechanism to explain how large scale forcing influences local zooplankton communities in the upwelling one off Oregon.

S1-6975

Specific long-term variability of Baltic Sea zooplankton stocks due to environmental and anthropogenic influences

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The Baltic Sea is a highly complex intra-continental shelf sea ecosystem at the eastern rim of North Atlantic Ocean. Zooplankton variability is influenced by climate-induced temperature and salinity changes as well as by anthropogenic effects like eutrophication, introduction of alien species and fishery related changes. Different zooplankton components react differently. While *Pseudocalanus* spp. stock is mainly correlated to precipitation and salt water inflows as well as to oxygen depletion forming habitat layer thickness, the microphagous rotifers and larvaceans mainly react to changes in eutrophication. *Acartia* species are generally affected by changes of microphagous stocks while early developmental stages of single *Acartia* species depend on the temperature regime and related food availability in early spring. *Temora longicornis* and *Bosmina* spp. are more tightly coupled to inter-annual variations of summer temperature than others. Because they are the main food source of small pelagic fishes they must be consequently affected. *Oithona similis* stock in the central Baltic Sea deep water is an indicator for the origin and strength of deep water renewals below the permanent halocline. Conversely, few specimens of *Limnocalanus macrurus* (an indicator for low saline of the Northern Baltic Sea) at the same place speaks for a vertical thermo-haline water exchange by the so called Baltic Sea conveyor belt. Furtheron, there is evidence for a certain carrying capacity for calanoid copepods. The contribution is a result of long-term monitoring studies, base on interdisciplinary data compilation, and statistical analysis.

S1-6979

Have jellyfish in the Irish Sea benefited from climate change and overfishing?

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Climate change and overfishing may lead to ecosystem instability and may benefit non-exploited organisms such as jellyfish. In the Irish Sea, an increase in jellyfish abundance was evident (r^2=0.29, p=0.03) in a 16-year time-series (1994–2009) collected during juvenile fish surveys. Jellyfish abundance correlated positively with sea surface temperature (SST) over the preceding 18 months (r=0.65, p_{ACF}<0.001) and copepod biomass in the previous year (r=0.56, p_{ACF}=0.03), and negatively with spring (February-May) precipitation (r=−0.57, p_{ACF}=0.02). Principal components regression indicated that climatic indices explained 68% of the interannual variability in jellyfish abundance (p=0.003), where the components were based on the North Atlantic Oscillation Index, SST and precipitation. The frequency of cnidarian material present in Continuous Plankton Recorder (CPR) samples has also increased since 1970, with a period of frequent outbreaks between 1982 and 1991. Prior to this period, the herring stock in the northern Irish Sea declined rapidly to a low level, potentially stimulating structural change in the ecosystem. In 1985 there was a step decrease in CPR copepod biomass and in 1989 a step increase in the phytoplankton colour index, suggesting a cascading regime shift during the 1980s. Subsequent overexploitation of gadids, coupled with warm temperatures and the poor recruitment of cod, led to the rapid decline in cod biomass from 1990. While the biomass of sprats has decreased in the last decade, the herring stock has recovered partially. Reductions in demersal fishing pressure since 2000, intended to stimulate cod recovery, appear to have facilitated further rises in haddock biomass. Since the 1980s regime shift, sea temperatures have increased, the fish community has altered and jellyfish abundance has risen such that jellyfish and haddock may now play an increasingly important role in the ecosystem.

S1-6987

Assessing the environmental drivers of interannual variation in mesozooplankton community structure: Insights from field observations in a Canadian fjord

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The mesozooplankton dynamics in Rivers Inlet, a fjord in Central British Columbia, Canada, were studied in spring and early summer 2006, 2007, 2008, 2009 and 2010 to assess the annual variability in zooplankton abundance, community structure, and development under different physical environments and spring bloom scenarios. Samples were collected fortnightly during 2006-2009 and monthly in 2010 and provide the first multi-year high temporal resolution zooplankton time series in the region. The spring bloom was delayed and short in 2007 and 2009, occurring at least two weeks earlier in 2006, 2008, and 2010. This shift triggered changes in mesozooplankton biomass and composition and affected the timing of the peak in secondary production in the inlet. Two alternate states of mesozooplankton community structure were detected: one dominated by larger copepods of the genus *Calanus* and *Metridia*, larvaceans, and pteropods, and another dominated by smaller, more neritic, copepods of the genus *Acartia* and *Microsetella* as well as cladocerans. Mean densities of copepod nauplii and calanoid copepod juveniles also varied dramatically between states. The relative importance of interannual fluctuations in phytoplankton dynamics, wind speed, river discharge, and water temperature appeared to drive the observed changes in mesozooplankton community structure between years. This study provides baseline field observations with which to assess potential physical and biological forcing mechanisms of mesozooplankton dynamics in central BC fjords. This knowledge is critical in assessing impacts of changing climate on plankton communities and higher trophic levels.

S1-7003

Egg hatching of copepod in hypoxic zone

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In summer, the hypoxic zone is often found in the eutrophic coastal area. This study was carried out to assess the impact of hypoxia on copepod egg hatching. *In situ* egg hatching experiments were carried out using a revised PET Chamber (Plankton Emergence Trap/Chamber) in Gamak Bay in southern Korea, where a hypoxic zone frequently formed in summer. The PET Chamber was installed in the hypoxic and normoxic zones, and experiments were performed over 12 days.

Dissolved oxygen concentrations were below 1.5 mg/L in the hypoxic zone and 4.0 ~ 6.8 mg/L in the normoxic zone during the experimental period. The pH in the seabed of the hypoxic and normoxic zones was 7.4 and 7.8, respectively. The density of eggs in the seabed of the hypoxic and normoxic zones was about 300,000 and below of 50,000 eggs/m^2, respectively. The hatching rate ranged from 3.7 to 4.0% in the hypoxic zone and from 55 to 67% in the normoxic zone. Also, eggs of abnormal form were abundantl in the hypoxic zone compared with the normoxic zone. The results suggest that expansion of the hypoxic zone may have important repercussions on population and community dynamics in coastal systems.

S1-7008

Growth and mortality within a mesozooplankton community at the polar front

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Mesoscale physical processes and their impacts on zooplankton production were studied at the Polar Front in the Barents Sea during the IPY-NESSAR project in late summer 2007 (July/August). The spatial patterns of currents, hydrography and mesozooplankton were mapped within an area of ~500 km^2 using an ADCP and a towed instrument platform equipped with a Laser Optical Plankton Counter (LOPC), a CTD and a fluorometer (F). Discrete water and zooplankton net samples were collected to compare with and interpret the LOPC-CTD-F data. Based on the observed data, relationships between hydrographic, chlorophyll and zooplankton fields were analysed and growth rates were estimated using biovolume spectrum theory. The slope of the biovolume spectrum allows one also to estimate mortality rates. Spatial patterns of growth and mortality are discussed with respect to currents and temperature and within the context of a warming climate.

S1-7015

Effects of climate change on the zooplankton lipid dynamics in coastal water bodies: A case-study in a brackish lake of Argentina

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Coastal zones are widely recognised as being particularly vulnerable to future environmental change and are frequently under stress because of human population growth and coastal socio-economic development. Coastal water bodies present a high rate of dynamic changes in the natural environment and high biological productivity and diversity. There is now ample evidence of the ecological impacts of recent climate change, from polar terrestrial to tropical marine environments. Zooplankton represent a crucial link between primary producers and consumers at higher trophic levels. Lipids, particularly polyunsaturated fatty acids (PUFA), are indispensable for the reproduction and growth of animals. Zooplankton species of cold and temperate waters present large store of lipids, whereas tropical species have generally lower lipid reserve. Moreover, increasing the amount of PUFA in phospholipids is reported as an important mechanism in regulating membrane fluidity at low temperatures. Thislater mechanism was observed in the zooplankton of Lake Chasicó, a coastal water body in the Pampa region of Argentina. The zooplankton biodiversity of this lake was low and the calanoid copepod *Boeckella poopoensis* was the main species in abundance and biomass. Higher temperatures may increase the tropical species distribution and decrease the lipid amount or PUFA content of zooplankton. Furthermore, climate change might enhancce some of the effects of eutrophication (*e.g.* toxic blooms and anoxia). A link exists between global warming and the worldwide proliferation of harmful cyanobacterial blooms. Cyanobacteria are low in PUFA, which could decouple the trophic webs and be detrimental for the growth of zooplankton and fish.

S1-7049

Trophic links and variability of the Canary Current system planktonic community in cold and warm years: An end-to-end approach

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A clear shift in sea surface temperature (SST) has been observed in the Canary Current during the last two decades. In 1994 – 95, temperature anomalies increased and remained high until present. Before these dates, SST in winter reached or was lower than 18ºC, except in 1987, while after 1995 only a few winters were colder than 18ºC. In order to compare cold and warm years, we performed weekly samplings and analyzed three winters from 2005 to 2007. Significant differences were observed in most of the biological variables among years. During 2005, the mixing of the water column started in January, while in 2007 the mixing period was delayed by one month showing slightly higher temperatures and lower chlorophyll concentrations. Mesozoo-, pico- and bacterioplankton biomass showed a decreasing trend in their average values between 2005 and 2007. However, neither nanoflagellates nor microplankton biomass showed this decrease. The dilution method allowed us to estimate microzooplankton grazing rates, and gut fluorescence was used as a proxy for larger zooplankton grazing. Microzooplankton grazing accounted for 59 to 74% of total grazing but a considerable percentage of grazing was also due to mesozooplankton showing that both micro- and mesozooplankton play an important role in the trophic food web. The results suggest that small inter-annual differences in temperature (~ 0.5ºC) lead to important changes in the structure of the pelagic ecosystem in subtropical waters.

S1-7054

Compensatory dynamics of zooplankton long term changes. Example from a marine protected are in the South Adriatic Sea

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Veliko Jezero ("Big Lake") is a semi-enclosed marine lake formed in a submerged karstic valley in a Croatian marine protected area, the Island of Mljet. Over the second half of the 20 century, the Veliko Jezero ecosystem undergone human-induced modifications related to the water mass exchanges with the open sea, which consisted in a 2-fold increase of depth in the channel communicating the lake with open sea. In this work we examine historical and recent data on hydrology and zooplankton abundance and structure that cover the period 1950-2001. Both, temperature and salinity showed upward trends and a maximum of 2°C in temperature, while salinity rose from 35.84±1.19, observed in the 1950s, to 37.43±0.56 recorded in late 1990s. Such changes have modified the pelagic habitat and altered the zooplankton structure through invasive processes and local extinctions. In particular, an increasing number of open-sea species, *i.e.* copepods and appendicularians, become more frequent and abundant, and former dominant species, i.e. the copepod *Pseudocalanus elongatus*, have disappeared since the 1990s. Concurrent to these changes, the biomass of jellyfish has increased, with the schyphomedusan *Aurelia* sp. 5 as the dominant species reaching abundances nowhere observed. These long-term modifications are discussed in regards to resilience and compensatory responses of zooplankton community to disturbance in a changing environment.

S1-7074

Using an acoustic index of euphausiid abundance to understand the impact of fish predation and climate conditions on the euphausiid standing stock of the Bering Sea shelf

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Estimates of the standing stock of juvenile and adult euphausiids (*Thysanoessa* spp.) have been made since 2004 using data from long-standing acoustic-trawl surveys of walleye pollock (*Theragra chalcogramma*) in the Bering Sea. Multi-frequency acoustics is used to identify euphausiid aggregations, and net tows are used to verify these identifications and gather euphausiid size and species composition data. A target strength model and length-biomass regressions are used to convert euphausiid backscatter to numbers and biomass of euphausiids. Comparisons between acoustic biomass estimates and data derived from net sampling and ecosystem models suggest that these acoustic estimates are an effective way of monitoring euphausiids in this ecosystem. There is an inverse relationship between euphausiid and pollock biomass time series, and estimates of the impact of pollock predation confirm that it may be a major top-down influence on the size of the euphausiid standing stock. At the same time, temperature and ice cover data from spring and summer show that climate and ocean conditions are also likely to play a role. The interplay of these factors may control the size of the euphausiid standing stock on the Bering Sea shelf.

S1-7089

Abrupt abundance changes in copepod abundance in the coastal Baltic Sea at a time-scale of fifty years

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The seasonal and multi-annual abundance variability of dominant copepod species was analysed in the shallow Gulf of Riga (Baltic Sea), based on a long-term dataset collected since the 1950s. The key copepod taxa – *Acartia* spp. and *Eurytemora affinis* –, that are main constituents of fish diets, experienced pronounced changes at interannual and decadal scales. We observed several abrupt shifts in copepod population sizes, which differed not only between taxa but also by developmental stages, indicating to changes in the degree of production and trophic efficiency of zooplankton. Temporal variability in the abundance of different developmental stages of copepods is discussed in relation to shifts in abiotic and biotic environment (incl. trophic interactions).

S1-7122

Inter-annual variability in abundance of *Calanus* spp. in oceanic subarctic waters north of Iceland in relation to environmental conditions

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Inter-annual dynamics of *Calanus finmarchicus* and *C. hyperboreus* were studied in the oceanic subarctic Iceland Sea based on a 21 year time series transect (1990 - 2010) sampled annually in May. The long-term variability was analysed in relation to hydrography and phytoplankton dynamics, and large scale climatic changes in the North Atlantic Ocean, particularly the North Atlantic Oscillation (NAO) using regression and multivariate techniques (linear regression models and redundancy analysis). The analyses demonstrated temporal trends ($P<0.05$). The Atlantic species, *C. finmarchicus*, increased in abundance in the north and was more abundant in warm years than cold years, whereas no firm relationship was found for the Arctic species *C. hyperboreus*. Several statistical relationships between hydrographic properties and the abundance of the two *Calanus* species were established, the strongest one was between the abundance of *C. finmarchicus* and temperature ($R^2=0.47$).

S1-7138

Adaptation potential of the calanoid copepod *Acartia tonsa* to multiple environmental stressors

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The euryhaline, eurythermal copepod *Acartia tonsa* plays an important role in many marine food webs as a grazer on phytoplankton and an important prey species for commercially-important fishes. Different populations of this cosmopolitan species experience a wide range of environmental conditions. This study, conducted in the framework of the German Biodiversity and Climate Research Centre Frankfurt aims to elucidate the adaptation potential of *A. tonsa* to multiple environmental stressors. The impact of interactive manipulations of temperature (4 to 34°C) and salinity (18, 25 and 33 psu) on vital rates (reproduction, survival and growth) of an *A. tonsa* population originating from marine (33 psu) waters of the North Sea was tested in laboratory experiments to show the potential influence of climate-driven changes in environmental conditions on its life cycle and population dynamics. Preliminary results show that the egg production rate (EPR) seems to decrease with increasing salinity. This resulted in EPR comparable to those of brackish populations, which points towards an optimal adaptation to estuarine conditions, despite the marine origin of the population. However, salinity did not influence the optimal temperature of maximum egg production. The potential production of resting eggs might be indicated by variable egg morphology at different temperature and salinity combinations, which strongly influences recruitment success and potentially the phenology of the species. Our results underscore the importance of investigating the combined effects of different physical factors to gain a mechanistic (physiological-based) understanding of potential changes in population dynamics resulting from climate induced changes in key environmental factors.

S1-7176

Do species-specific differences of copepod life cycle and ecology contribute to multi-decadal variability in abundance across the north Atlantic basin?

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Long-term studies have reported regional differences in the inter-annual trends of abundance of some copepods species. Such inter-annual changes in copepod abundance have been linked to hydro-climatic variation for some species but not for others. Copepod can be characterised by very different species-specific eco-physiological traits and life strategies. Therefore, long-term changes in abundance should reflect how each species respond to and/or is affected by changes in environmental factors (biotic and abiotic). Using the Continuous Plankton Recorder survey data from 1958-2008 we analyse the seasonal trends of dominant copepod species in the north Atlantic in relation to environmental variables to investigate the link between species life cycle with their long-term changes in abundance. The results are discussed in relation to published literature to elucidate the mechanisms which might have given rise to the observed basin scale multi-decadal variability in abundance of copepod species and to make predictions about how different species could be affected by future environmental change.

S1-7183

Long-term trend in the mesozooplankton abundance in a southwestern temperate estuary (Bahía Blanca Estuary, Argentina)

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Estuarine ecosystems are sensitive to anthropogenic and hydroclimatic modifications and emerge as important areas to study the functioning of pelagic food webs. Here, we analyzed mesozooplankton and phytoplankton data from the Bahía Blanca Estuary that cover the years 1980-2007 in relation to environmental conditions. The mesozooplankton is mainly dominated by two key copepods: *Acartia tonsa* and *Eurytemora americana*, which have shown a recurrent annual pattern during the considered period. *Acartia tonsa* has largely dominated during most of the year with maximal abundances in summer-early autumn while *E. americana* has been dominant in late winter-spring coinciding with the phytoplankton annual bloom. *Eurytemora americana* feeds mostly on diatoms and disappears from the plankton habitat after the collapse of the phytoplankton bloom and remains as resting eggs in bottom sediments. In the last decade, noticeable variations on this pattern have been observed. The abundance of both copepods, especially in 2005 and 2007, increased significantly and it was mainly related to water temperature and salinity. On the other hand, the phenology of the phytoplankton bloom has changed (*e.g.* magnitude, timing and species composition) what has probably affected the trophic interactions and the pelagic food web structure. The shifts on zooplankton abundance could be linked to changes in hydrological conditions in the estuary (*i.e.* temperature and salinity) and phytoplankton due to its strong dependence on these variables. However, the present work is the starting point and future studies are necessary to attempt this issue.

S1-7201

Copepod reproduction and oxidative stress in a future climate scenario: Effects of lowered pH, elevated temperature and a toxic cyanobacterium

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Global climate change is predicted to increase sea surface temperature and induce ocean acidification. Changing climate may promote harmful algal blooms, such as cyanobacteria blooms in the Baltic Sea. The blooms are a common phenomenon and their frequency has increased due to anthropogenic eutrophication. The calanoid copepods that co-occur with cyanobacteria in the Baltic are to some extent tolerant to cyanobacteria. They are not lethal, but they lower reproductive success. The aim of our study is to evaluate the effects of lowered pH combined with elevated temperature and the presence of the toxic cyanobacterium, *Nodularia spumigena*, on the calanoid copepod *Acartia bifilosa*. In a short term experiment with *A. bifilosa*, lowered pH did not affect egg production and egg hatching success. However, their response to acidification may be enhanced when combined with other stress factors, such as temperature and/or toxic cyanobacteria. In addition, the sub-organism-level responses that precede negative effects in reproductive measurements may be more likely to be detected. Therefore, we measured egg production and grazing, as well as antioxidant responses and oxidative stress in copepods exposed to different climate scenarios and diets. We hypothesised that exposure to combined stressors will increase antioxidant levels compared to single-stressor exposure and could result in oxidative stress and decreased reproductive performance.

S1-7236

Plankton observing in Australia: The Australian Continuous Plankton Recorder (AusCPR) survey

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Plankton respond rapidly to changes in ocean conditions, making them invaluable indicators of ecosystem health and environmental change. The largest plankton monitoring programme in the world is the Continuous Plankton Recorder (CPR) survey in the North Atlantic, which has operated since 1938, and has provided unique insight into the response of pelagic ecosystems to global change. Additional CPR surveys operate in the North Pacific and the Southern Ocean. Here we provide an overview of the newest CPR programme, the Australian Continuous Plankton Recorder (AusCPR) survey. AusCPR forms part of a larger Integrated Marine Observating System (IMOS) that monitors physical, chemical and biological attributes of Australian coastal seas. A focus of the programme is to understand the dynamics of the two poleward-flowing, warm-water currents that bound the continent, especially since the East Australian Current has increased in strength by 30% over the past 60 years and is projected to continue to do so under climate change. AusCPR currently samples regularly along the east and south east coasts of Australia, the east coat of Tasmania, across to New Zealand and in the Southern Ocean during the austral summer. AusCPR thus samples 40° of latitude from the subtropics to polar latitudes. Since mid 2009, the survey has towed 18.700 nautical miles and counted 2.200 samples for 450 zooplankton taxa and 150 phytoplankton taxa. Preliminary results from AusCPR are shedding new light on plankton abundance, distribution and timing in relation to meso-scale eddy activity, the effect of ephemeral events such as dust storms, and the relationship between plankton abundance and mesopelagic fish (measured acoustically on some transects). AusCPR provides Australian scientists, policy makers, and marine managers with information on plankton changes in response to climate variability and change, indices for fisheries management, a system for detecting harmful algal blooms, a tool for validating satellite remote sensing products, and data to initialise and test ecosystem models.

S1-7237

Plankton observing in Australia: Plankton from the Australian National Reference Stations

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Plankton are sensitive indicators of ecosystem health and environmental change, and their time series provide baselines for answering questions concerning effects of climate change, fisheries, eutrophication, pollution, harmful algal blooms, and species introductions. Compared with other maritime nations, Australia has few long-term plankton time series, with the longest historical time series for zooplankton only two years in length. Here we provide an overview of the new National Reference Station programme, within the larger Integrated Marine Observing System that monitors physical, chemical and biological attributes of Australian coastal seas. The National Reference Stations comprise nine sites on the shelf (30-100 m depth) that are sampled monthly for water chemistry, phyto- and zooplankton biomass, species composition, and size spectra. Each station has a mooring that continuously measures temperature, salinity, fluoresence, and photosynthetically active radiation, and many have acoustic doppler current profilers measuring currents. Since mid-2008, more than 450 phytoplankton and zooplankton taxa have been counted. We present preliminary results for phytoplankton and zooplankton comparing their abundance, biomass and seasonal cycles at the National Reference Stations. The National Reference Stations programme provides Australian scientists, policy makers, and marine managers with information on plankton changes in response to climate variability and change, indices for fisheries management, a system for detecting harmful algal blooms, a tool for validating satellite remote sensing products, and data to initialise and test ecosystem models.

S1-7238

Spatial and temporal distribution of copepod diversity and abundance in the Gulf of Carpentaria, Australia

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The Gulf of Carpentaria is a large, shallow tropical basin (85% of the area <60 m depth) enclosed on three sides by northern Australia and bounded in the north by the Arafura Sea (located to the south of the island of New Guinea). This region is a productive area for fisheries, particularly penaeid prawns, and is just south of the global biodiversity hotspot in Indonesia and Malaysia. Here we investigate copepod diversity and abundance in relation to key environmental variables and water masses. Plankton samples were collected by oblique tows (mesh size of 142 µm) at 23 stations during 10 cruises between August 1975 and May 1977. Copepod abundance was relatively low and typical of oligotrophic tropical regions globally. A total of 102 copepod species were identified, 68 belonging to the Calanoida, 30 to the Cyclopoida, and 4 to the Harpacticoida. Of these, 13 species were new to science and all species collected in this study represent new records of copepods for the Gulf region. The faunal composition is typically warm-water neritic and similar to that of the Malay achipelago. Multivariate principal coordinate ordination of the stations identified three typical assemblages: inshore, intermediate and offshore. Boundaries of these groups varied through time, so that the inshore group spread further offshore during rainy periods and was replaced by the transition group during May and later in the year by the offshore group. Each assemblage had a suite of characteristic environmental conditions defined by depth, temperature, salinity and silicate. The multivariate analysis based on species revealed a non-ubiquitous lineage of 36 species, which were important indicator species of water masses. This work represents the first systematic sampling and description of copepod abundance and diversity in the Gulf of Carpentaria.

S1-7244

Seasonal variation in copepod community structure in Tokyo Bay, Japan

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Seasonal change in copepod community structure in the inner part of Tokyo Bay was investigated using samples collected by NORPAC net (mouth diameter: 45cm, mesh size: 200µm) in 2006-08. Cluster analysis based on similarities in copepod composition among samples revealed clear seasonal groups (Groups A, B, C) at the 70% similarity level. Group A appeared in winter-spring, characterized by cold species such as *Centropages abdominalis*. Group B occurred in early summer, dominated by *Acartia omorii* accounting for 82% of the mean total abundance. Group C appeared in summer-fall, dominated by *Paracalanus parvus* and *Temora turbinata*. *A. omorii* occurred year- round but was scarce in summer to fall, and *C. abdominalis* disappeared in summer. Both species are known to maintain their population as resting eggs in summer. The shift from Group A to B occurred in June of 2006 and 2008, and in May of 2007. In 2007, Group A had a much higher abundance of *A. omorii* than *C. abdominalis*. High water temperature in the winter of 2007 might have caused the early appearance of Group B. The shifts from Group B to C and C to A occurred in August and December, respectively, every year. Seasonal succession of the copepod community seems to be regulated by water temperatures, and the increasing trend of water temperatures in winter in Tokyo Bay could have induced the shift of timing from Group A to B.

S1-7253

Abundance-diversity-environment relationship: The case of copepod assemblages in the Rio de la Plata estuary

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The relationship between ecosystem functions like biogeochemical cycles and the structure of biological communities is a core problem in Ecology. Such knowledge is essential to predict ecosystem changes in the face of biodiversity loss and environmental variability (*e.g.*, habitat fragmentation, climate change). Niche complementarity and facilitation processes indicate that performance of a given function should increse with the number of species or functional groups present in a given assemblage. But the pattern, if existent, remains elusive. We evaluated the relationship between copepod abundance (as a surrogate for production) and specific richness in the Río de la Plata estuary. During four cruises in different seasons we sampled, identified and counted mesozooplankton along a wide environmental gradient using standard methods. Copepods were numerically dominant, their abundance ranged over three orders of magnitude between 37 and 65000 ind m^{-3}, and their richness between 2 and 14 species per station. The structure of the assemblage changed along the salinity gradient, with highest number of species occurring near the marine end. Contrary to expected, there was no consistent possitive relationship between abundance and richness: a positive and highly variable trend existed during two cruises, but no trend was detected on two other cruises, or in the pooled data. We hypothetise that in large scale turbid estuaries no-simple relationship between production and biological diversity is to be expected; rather, the combined effects of physiological stress imposed by environmental variability, and well-known physical-biological mechanisms that modulate production are more determinant of zooplankton production than general niche processes.

S1-7266

Fish larvae assemblage during El Niño and La Niña 2007 in the Pacific Ocean of Colombia

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Icthyoplankton assemblages vary considerably at different time scales. In tropical waters of the eastern Pacific El Niño and La Niña are the most important oceanographic processes at a regional scale. In this research we analyze the variation in abundance (Individuals/1000 m^3) and structure of ichtyoplankton assemblages in the Pacific Ocean of Colombia during the terminal phase of a El Niño event (January – February 2007, Oceanographic campaign Pacífico XLIV) and compare with a La Niña event (September 2007, Oceanographic campaign Pacífico XLII I - ERFEN XLV). The icthyoplankton was sampled using a bongo net (30 cm and 250 µm of mesh size) with vertical tows from 250 m to surface. During El Niño conditions sea surface temperature was +4.3ºC above the historical value, while during La Niña conditions sea surface temperature was –2.5°C below historical value. Total abundance of fish larvae during El Niño phase was from 34 to 1,230 Ind/1000 m^3. In contrast during La Niña phase total abundance was from 87 to 1,435 Ind/1000 m^3. The most abundant families in the El Niño were Myctophidae (53%) and Bregmacerotidae (10%) whereas in La Niña were Mychtophidae (71%) and Engraulidae (8%). Of the 27 families registered in each period, Myctophidae was the most abundant. The Mycthophidae species are manly eurythermal organism; therefore they are highly tolerant to thermal changes. Results of this research suggest that during El Niño-La Niña phases the icthyoplankton abundance in the Pacific Ocean of Colombia is constant; however the assemblage structure could change drastically.

S1-7278

Mesoscale variability and its impact on the euphausiid community off Central Chile during the spring 2007

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Mesoscale structures, such as upwelling filaments and eddies, have a potentially strong impact on the zooplankton community by generating retention mechanisms and/or influencing the conditions for feeding in more oceanic zones. We evaluated the potential effects of mesoscale eddies on the euphausiid community off Central Chile in the spring 2007, using satellite data and 443 zooplankton samples obtained during 10 consecutive days. Analysis of sea level anomalies allowed us to derive geostrophic current fields, eddy kinetic energy (EKE) and relative vorticity, and thus identify eddy-like structures. Sea surface temperature (SST) and chlorophyll *a* (CHL) data were used as environmental variables affecting the structure of the euphausiid community. We detected at least eight eddy-like structures (4 cyclonic and 4 anticyclonic). The euphausiid community was represented by 14 species, the most abundant of which were *Euphausia mucronata*, *E. gibboides*, *E. recurva*, *Nematoscelis megalops* and *Stylocheiron abbreviatum* (>70%). Multiple regression and variance analyses showed a highly significant association between the abundance of some euphausiids species (mainly *E. mucronata*) and EKE, SST and CHL. Significant differences in the abundance between cyclonic and anticyclonic eddies were found for *E. gibboides*, *S. abbreviatum,* suggesting a possible vorticity-dependent partitioning of the community. However, these results indicated that mesoscale variability is not the only explanatory mechanism of the observed patterns of the euphausiid community, but as it was clear that coastal upwelling coupled to mesoscale structures, such as eddies, was a key physical process influencing species forming swarms and/or numerically dominant zooplankton, such as *E. mucronata*.

S1-7285

Interannual variability in the Scotian Shelf (Northwest Atlantic) zooplankton community and influence on the Gulf of Maine

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The zooplankton community of the Gulf of Maine and Georges Bank (Northwest Atlantic) exhibited a shift in the 1990s to greater dominance of small-bodied copepods, compared to the previous and following decades. This shift was associated with increased inflow of low-salinity water from the Scotian Shelf and may have been driven by changes in either advective supply of zooplankton or increased stratification and fall-winter primary production, resulting in reduced mortality for small-bodied copepods. A comparison of average zooplankton seasonal cycles between the Gulf of Maine and the Scotian Shelf in using data from 1999 to 2007 indicates that fall and wintertime abundance of small-bodied copepod species was higher on the Scotian Shelf than in the Gulf, supporting the hypothesis that increased advective supply influenced the zooplankton community of the Gulf in the 1990s. However, the abundance of small copepods on the Scotian Shelf also exhibited a shift from higher abundance in 1999-2001 to lower abundances in 2002-2003, similar to the Gulf of Maine. To evaluate the influence of fall-winter stratification on small copepod abundance, we present interannual variability patterns in the zooplankton community on the Scotian Shelf observed from the end of the 1999 to 2009, and compare copepod abundance to fall/winter stratification and chlorophyll concentrations during this period. The long-term objective is to better understand the physical and biological mechanisms driving variability in zooplankton communities in the Northwest Atlantic continental shelf ecosystem.

S1-7287

Abundance and composition variability of copepods in the northern Humboldt Current system

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In the Northern Humboldt Current System, copepods are considered an import component of zooplankton due to their high abundance and diversity. Furthermore, a new analysis of stomach contents of Peruvian anchovy and their conversion to Carbon amounts showed evidence copepods are one of its main energy supplies.

The present work evaluates the abundance and composition variability of copepods in the Peru Humboldt Current System during periods of diverse oceanographic characteristics: cold (1981, 1983 and 2000) and warm conditions (1983, 1996 and 2003). Oceanemperature, salinity, dissolved oxygen and nutrients were registered.

In 1981 and 1983 abundance and number of copepod species dramatically decreased, which was related to low primary production, whereas in 1996 and 1998 there was a remarkable increase coincident with high primary production. The years 2000 and 2003 had an intermediate level in abundance and number of species. *Paracalanus parvus* and *Acartia Tonsa* were the most dominate species in all sampling years, while *Centropages brachiatus* was only present during cold periods. Results showed the abundance and composition of copepods was more related to long term changes characterized as warm (1981 and 1983), intermediate phase (1996 and 1998) and cold (2000 and 2003) decade than to changes in oceanographic conditions.

S1-7290

Egg production rates of *Pseudocalanus mimus* and *Pseudocalanus newmani* in the coastal Gulf of Alaska

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Pseudocalanus is the most abundant calanoid genus in most boreal through arctic neritic habitats. On the Gulf of Alaska shelf, it is represented primarily by 3 species, 2 of which predominate: *Pseudocalanus mimus* and *P. newmani*. We have examined their species-specific egg production rates each spring and late summer for 10 years, and at higher temporal resolution for 4 of those years, executing more than 200 experiments for each species. Oceanographic climate varied considerably over this period. Both average clutch size and female length consistently varied seasonally in both species, with peaks occurring during May, the typical period of the spring phytoplankton bloom. During May, clutches averaged 30-40 eggs, compared to summer means of 10-15 eggs, with differences driven largely by changes in female prosome length and not food concentration. From May through October, temperature-adjusted daily specific egg production rates remained relatively stable at 10-20%. Population birth rates are stabilized by a larger percentage of the females producing smaller clutches during summer. Compared to many other calanoid copepods, egg production in *P. mimus* and *P. newmani* appears to be poorly correlated to chlorophyll concentration.

S1-7299

Estimating the effect of environmental conditions on the seasonality and outbreak periodicity of *Pelagia noctiluca* in the Mediterranean Sea

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Presenter: Juan Carlos Molinero on behalf of Lucía López-López

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Increasing abundance of gelatinous zooplankton has recently been acknowledged as a worldwide trend. The few long-term datasets available on these taxa have proved useful in exploring the possible drivers of these increments, pointing out unanimously at climatic change and recognizing as well the influence of overfishing and habitat alteration. Among the harmful jellyfish, *Pelagia noctiluca* has been qualitatively recorded during the last century in the Mediterranean Sea. The long-term dynamics of this species in the Mediterranean follows a contrasting periodicity in both basins. The lack of genetic evidence to separate Mediterranean and Atlantic populations suggests that differences in outbreaks periodicity and seasonality stem from uncoupled environmental conditions between both Mediterranean basins. In this study, we examined long-term data *of P. noctiluca* from coastal locations in the light of hydroclimatic forcing throughout the twentieth century in the Mediterranean Sea. Outbreaks of the species appear related to an optimum sea surface temperature at ca. 18°C in both eastern and western basins. However, in the Adriatic Sea the dynamic was markedly different. We hypothesise a predominant role of increased autocorrelation in the major climate drivers affecting the Mediterranean Sea in *P. noctiluca* recurrence period. The whole picture of *P. noctiluca* outbreaks dynamics is however revealed through the analysis of synergistic of climate change, overfishing and food web structure. Our study constitutes a necessary step towards a mechanistic understanding of the influence of environmental change on gelatinous carnivore populations.

Session 2 Posters

S2-6899

One more guilty player in the dramatic changes in the plankton of the Black Sea – *Acartia clausi*

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In this study was shown that, along with *Mnemiopsis leidyi*, large predatory copepods have an important influence on reducing of the abundance of plankton. Decline of abundance of some mesoplankton species in the Black Sea were observed after *M. leidyi* outburst (1989). In this time previously dominant copepod *Oithona nana* disappeared. But some species were intact and their abundance has even increased, and *Acartia clausi* became the dominant species in mesoplankton. Numerous laboratory experiments of different authors have shown that *A. clausi* does not only filtrator, but it can also hunt for active prey. These carnivorous copepods can consume organisms in range from 0.006 to 2.5 mm, including the eggs of copepods and fishes (80 microns), crustaceans of genus Oithona, and even the larvae of fishes. Some researchers note the absence of correlation between the biomasses of *M. leidyi* and biomass of some copepod species. For example, *Acartia tonsa* has not suffered from outbreaks of *M. leidyi*, and abundance of this copepod even increased, although its development is confined to the same with *M. leidyi* season and layer. At the same time, the correlation between abundances of *O. nana* and *A. clausi* quite high with a negative sign. When comparing the long-term data on *M. leidyi*, *A. clausi* and *O. nana*, is similar, that *A. clausi* "eaten the remnants" of *O. nana* after *M. leidyi*. Remain insufficiently studied some questions about the contribution of different taxonomic groups in the change of the situation in the Black Sea, but it is clear that significant changes in the Black Sea ecosystem were caused by a changes in the late 1970s of biotic and hydrological conditions.

S2-6912

Influence of physical oceanography on the diet of size fractionated zooplankton of Western Australian coast: Insight from fatty acids

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West coast of Australia is influenced by poleward flowing, warm and nutrient poor Leeuwin Current that suppresses upwelling. Consequently the waters are oligotrophic, primary production is low and the phytoplankton blooms in autumn and winter. Our study was a part of a multidisciplinary project aimed at exploring the drivers of primary production leading to the observed bloom and assessing the trophic structure of the system. We examined the variability in mesozooplankton feeding from south to north off Western Australia in three water masses: inshore, in the Leeuwin Current and offshore of the Leeuwin Current, to determine the food web type and to unveil information about the food quality to higher trophic levels. Mesozooplankton forms a key trophic link in marine ecosystem feeding on a range of prey including phytoplankton, microzooplankton, bacteria and marine snow and is an important mediator of carbon flux however information on the feeding ecology and nutrition of mesozooplankton off the coast of WA is limited. Fatty acid biomarkers indicated that dinoflagellate based food web dominated with multivorous food web prevalent inshore and microbial food web in the Leeuwin Current and oceanic waters. Diatom markers were more important inshore and diatom to dinoflagellate ratio increased from north to south. Significant proportion of small phytoplankton markers was present especially in oceanic waters. Carnivory indices were high and increased significantly from inshore to offshore. DHA to EPA ratio, important in fish larvae development, was high and the potential value of zooplankton as food for higher trophic levels is discussed.

S2-6922

Zooplankton as food supply to the marine pelagic fishes in the Kamchatka waters

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The Kamchatka Peninsula (eastern Russia) is surrounded by the Pacific Ocean and the Bering Sea on the east, and by the Okhotsk Sea on the west. The most important commercial fishery resources of the Kamchatka region are the pelagic fish species: walleye pollock *Theragra chalcogramma*, Pacific Salmon *Oncorhynchus* spp., Pacific herring *Clupea pallasii*, and atka mackerel *Pleurogrammus monopterygius*. Total annual catch of these species in Kamchatka can exceed 2 million tons. The aim of our study was to estimate the contribution of zooplankton as food supply to the marine pelagic fishes of Kamchatka. We have analyzed data regarding the zooplankton composition and the spatial distribution of zooplankton biomass from a long-term monitoring survey in the waters adjacent Kamchatka collected mainly in the upper 100 m. Our analysis of the interannual and seasonal dynamics of plankton indicates that the peak zooplankton biomass occurs in June, and that the time span of the maximum and the production is determined by conditions in each year. We have also examined feeding by almost 20 marine pelagic species of fish (juvenile and adult). The diet of the studied fish consisted of copepods, hyperiids, euphausids, pteropods, appedicularians, and various planktonic stages of decapods, squids and fish. Different prey dominated the fish rations depending on the habitat and feeding selectivity patterns. This study is a contribution to our understandingthe trophic role of zooplankton in the marine pelagic communities off Kamchatka.

S2-6925

Zooplankton of the Sea of Japan as potential prey for livestock growing of salmon

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The Sea of Japan has good prospects for the development of industrial salmon management. At the Russian coast, construction of ten fish hatcheries is planned for the production of three species of the genus *Oncorhynchus*: chum salmon, pink salmon, and masu salmon. For this reason, the task to estimate the reception capacity of the feeding area for salmon in the Sea of Japan was undertaken. Based on the long-term (1985-2009) plankton and trawl survey data, the standing stocks of zooplankton, their seasonal variability and species composition in the different areas of the Sea of Japan were estimated. In addition, diet composition of nekton and their consumption was studied. As the Sea of Japan is poorly populated by planktivorous nekton, prey resources (zooplankton) are underused. After the disappearance of sardine and the accompanying sharp decline of feeding pressure, the trophic structure of the plankton community has changed: the number of predators (Chaetognatha) has increased and the total biomass of zooplankton has decreased. It is expected that the artificial cultivation of salmon in the area will not cause a scarcity of food. The zooplankton community responds to the pressure of planktivorous nekton by changing their own trophic structure. After a long period of relatively low zooplankton biomass in the Sea of Japan (470 mg/m^3 in average), since the early 2000's, zooplankton biomass began to rise and the standing stock of large-size plankton increased 15-20%. In spring and summer, which are the most important periods for juvenile fish in the nursery areas, zooplankton in the coastal zone are abundant and dominated by small-size copepods – the main food of young fish, including salmon. Whereas pink and the chum salmon are planktivorous throughout their life cycle, masu salmon feed on nekton. Judging by the high concentrations of plankton in the areas occupied by fry from the fish farms on some rivers of the Prymorie area, there are favorable conditions for planktivorous fish, including salmon.

S2-6933

Mesozooplankton community structure and trophic interactions in the Southern Patagonian Shelf (SW Atlantic, Argentina, 47°-55°S)

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The ecosystem of the Southern Patagonian Shelf is highly productive and includes a variety of commercially important fisheries and large mammal and bird populations. Knowledge of the pelagic food web structure that supports the richness of this system is still developing, but there are broad indications that mesozooplankton occupy a pivotal position as vital prey for fish and consumers of smaller plankton. For the first time, all plankton communities in the size 2 µm – 20 mm were surveyed simultaneously in the region in October 2005. Plankton data and trophic relationships were examined through multivariate statistics. Nanoplankton and microplankton were taxonomically (diatoms, dinoflagellates, ciliates, flagellates) and functionally (autotrophs, heterotrophs) sorted within each size fraction. Copepods largely dominated the >200 µm fraction. Three mesozooplankton assemblages typical of the inner, middle, and outer shelf were identified. The inner and middle shelf assemblages overlapped slightly but were spatially separated from the outer shelf community. Adults and late copepodids of *Drepanopus forcipatus* were typical of the inner shelf assemblage. Middle-shelf species included the copepod *Ctenocalanus vanus*, the amphipod *Themisto gaudichaudii* and the chaetognath *Sagitta tasmanica*, while an assortment of taxa characterized the outer sector. Latitudinal patterns in mesozooplankton community composition were less apparent than cross-shelf patterns. No clear pattern of phytoplankton and protozooplankton assemblages was apparent when the whole < 200 µm plankton community structure was considered. In contrast, communities in the optimal size food for copepods (>10 µm) were slightly different across shelf. Overall, spatial patterns of mesozooplankton and copepod prey communities matched weakly. Significant correlations were found particularly with large autotrophs and heterotrophs.

S2-6937

Bridging the gap between food quality and secondary production in a highly productive fjord in British Columbia, Canada

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Recent use of “bioindicators” (*e.g.* fatty acids, stable isotopes) has highlighted the importance of food quality over food quantity for the diet of copepods, the primary consumers in most marine ecosystems. Fatty acid analyses have been used to examine the effect of food quality on reproductive success and copepod development; however, these studies are typically conducted in the lab using one or a few copepod species, thereby creating a gap in the literature as to whether this relationship exists in a field setting where consumers experience a wide range of prey items of different nutritional value. To address this gap, *in situ* measurements of chitobiase, a crustacean moulting enzyme, were used to examine whether variability in food quality affects the crustacean zooplankton community, expressed in terms of secondary production. Sampling took place on Saanich Inlet, BC, from March to August 2010, thus spanning the range of seasonal variability of phytoplankton consumed by the copepod community. Preliminary results indicate secondary production peaked in early May (shortly after the spring bloom) and June in the upper water column. In the lower water column, on the other hand, smaller peaks in secondary production occurred in late April and July, indicating different species are likely occupying different depths in the water column. Seasonal variations in fatty acid profiles of copepods will be compared to production estimates in order to determine the magnitude of short-term shifts in food quality for copepods and whether such shifts can be linked to secondary production at the community level.

S2-6938

Grazing and egg production of the copepod *Acartia tonsa* in a highly eutrophic bay, Rio de Janeiro, Brazil

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Guanabara Bay is a eutrophic ecosystem in the southeast of Brazil. Despite the high level of anthropogenic eutrophication, high densities of microzooplankton and copepods are found, particularly in the inner bay. Here we tested the hypothesis that the copepod *Acartia tonsa* benefits from feeding in more eutrophic areas due to the higher availability of food (i.e. heterotrophic dinoflagellates and ciliates). The aim of this study was to determine ingestion rates, prey selectivity, and egg production of *A. tonsa* in two areas with different levels of eutrophication, the inner bay and the entrance of the bay. Four experimental treatments were established in which copepods collected from each area were separately incubated in water from both areas in a cross-over set up. Copepods were individually isolated and ~ 10 females and 2 males of *A. tonsa* were maintained in plastic bottles (630 ml) incubated *in situ*. Ingestion rates of *A. tonsa* collected from both areas and fed in a more eutrophic water were up to 60-fold higher than those of copepods fed on the water from the entrance of the bay. Consequently, those females showed significantly higher egg production. According to the electivity index, *A. tonsa* fed preferentially on large dinoflagellates and small centric diatoms. Thus, although our results suggest that it might be advantageous for *A. tonsa* to feed in the inner bay, it also seems that *A. tonsa* prefers to feed on diatoms, which occur in very low density at this site.

S2-6951

Active food selection in appendicularians

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Appendicularians are traditionally considered as non-selective filter feeders. We showed that, on the contrary, appendicularians are able to select actively the particles that they ingest. Using microscopic video observations and by providing different food items (ciliates, toxic and non-toxic dinoflagelates), the different pathways of food rejection of the appendicularian *Oikopleura dioica* was studied. We showed that appendicularians reject particles mostly based on their size and secondarily based on their toxicity and nutrient depletion. Together with previous comparable results on retention efficiency, these results were used to define the optimal prey size for appendicularians. This optimum prey size range is one of the largest toward other planktonic organisms and indicates that appendicularians are not only microphageous organisms but may also compete with macrophageous grazers and thus can have an impact on large preys.

S2-6966

Seasonal dynamics of *Calanus finmarchicus* in relation to environmental factors in the Norwegian Sea: A multiyear basin-scale analysis

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Seasonal cycles of *Calanus finmarchicus* and environmental variables are compared in different domains of the Norwegian Sea. Mixing-depths in Norwegian Coastal Water are relatively shallow throughout the year due to a primarily salinity-driven stratification or the bottom. In contrast, the mixing-depths in Atlantic and Arctic waters show larger seasonal amplitudes since stratification there depends mainly on solar warming of upper layers. By mid-March, the spring phytoplankton build-up is in progress in Coastal and Atlantic waters (scarce data in Arctic waters). While a short and high chlorophyll peak is typical during April in Coastal Water, the increase is slower and the chlorophyll peak extended over the period April-June in Atlantic and Arctic waters. Near-surface consumption of nitrate, phosphate and silicate is apparent in Coastal Water by late March and in Atlantic and Arctic waters during April-May. A quicker decrease of nutrient-levels in Coastal Water probably reflects the more intense development of the phytoplankton bloom there. Adults and CVs of *C. finmarchicus* are observed in low numbers in the uppermost 200m of Coastal and Atlantic waters as early as January-February (scarce data in Arctic Water), and during March and April their numbers increase in all water masses. While, no evidence of an advanced ontogenetic ascent in the Coastal Water was found, young copepodites of the new generation appear somewhat earlier in Coastal Water (~ March) than in Atlantic Water (late March - April), possibly reflecting different developmental rates. A second seasonal pulse of young copepodites was detected in Coastal and Atlantic waters.

S2-6978

Spatio-temporal patterns in abundance of larval fish from Continuous Plankton Recorder (CPR) surveys in the North, Celtic and Irish Seas (1950-2005)

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Data from Continuous Plankton Recorders (CPR) are well known for long time-series of copepod and phytoplankton abundance data that they provide. However, CPRs also sample fish larvae, albeit less efficiently, and these captures have traditionally been reported simply as 'fish larvae'. The visual identification of separate species or families in historic CPR larval samples (1950-2005) has been completed this year (2010) and the two most abundant families are the Clupeidae (herring/sprats) and Ammodytidae (sandeels). We explore here potential relationships between fish larvae in the North, Celtic and Irish Seas to prey abundance (copepods), phytoplankton (diatoms and dinoflagellates) and sea surface temperature. Potential ecosystem regime shifts encompassing all areas and trophic levels are investigated using multivariate statistical methods. We also examine the possible use of the larval data for stock assessment, in particular for the sandeel stock of *Ammodytes marinus* in the North Sea.

S2-6983

The influence of prey size, sex and behaviour on predation by the scyphomedusa *Aurelia aurita*

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The apparent increased incidence of gelatinous blooms, linked to changes in ecosystem structure, drives the need to understand the trophic ecology of gelatinous predators. Identifying the likelihood of prey capture by gelatinous predators, when feeding on copepod prey, will help to predict the impact of such blooms. Subtle differences in predator preferences may also help explain differences in mortality rates between copepod species, developmental stage and sexes. Copepod size and behaviour can influence susceptibility to predation, as these traits affect encounter rates, escape success of the prey, and predator preferences. We explore how feeding rates in the scyphomedusa *Aurelia aurita* change with copepod prey size, speed and escape response (which all increase with copepod developmental stage), by presenting medusae with live or heat-killed (to remove behaviour) late-stage nauplii, C1 and adult *Acartia tonsa* as prey. Medusae are passive predators; therefore, prey capture depends on the interaction of tentacle density, tentacle spacing, handling efficiency and prey characteristics. The results show that feeding rates on the live developmental stages of *A. tonsa* are similar across developmental stages (and sexes), but that predation increases with developmental stage for the heat-killed prey, thus suggesting behaviour in the later developmental stages can compensate for the increase in predation that their size alone should dictate. Furthermore, we examine if *Aurelia aurita* feeding rates vary between adult males and females of copepods exhibiting similar (*Acartia tonsa*) or different (*Oithona similis*) swimming behaviours. These results are discussed with reference to female skewed sex-ratios of copepods in the field.

S2-6999

Spring diurnal dynamics of ichthyo- and zooplankton in a deep canyon in Avachinsky Gulf (South-East Kamchatka) in 2006-2007

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Avachinsky Gulf (the Pacific Ocean coast of Kamchatka) typically has a complex structure – with a deep central hollow and shelf bar, developed in the North direction and cut by several long and narrow canyons. Ichthyoplankton and zooplankton diel changes in composition were studied every three three hours during 24 hours in 2006 (May 19-20) and 2007 (May 16-17). Ichthyoplankton samples were collected in the “northern” canyon at the depth range 630-0 m by the cone-shaped net (IKS-80) whereas zooplankton samples were collected in the upper 50-0 m layer with Juday nets (BSD). The zooplankton community generally consisted of copepod eggs and nauplii. The bulk of the biomass was composed of the copepods *Pseudocalanus minutus*, *Eucalanus bungii*, *Oithona similis,* and *Neocalanus plumchrus*. Aggregations of the zooplankters were maximally dense during night time. The ichthyoplankton community consisted mainly of rougheye rockfish *Sebastes aleutianus*, shortraker rockfish *S. borealis*, Pacific Ocean perch *S. alutus*, tadpole snailfish *Nectoliparis pelagicus*, walleye pollock *Theragra chalcogramma*, grenadiers *Macrouridae*, and northern smoothtongue *Leuroglossum schmidti*. Aggregations of larval rockfish and walleye pollock were dense during night time. In contrast, aggregations of larval and fry pelagic tadpole snailfish were highest during daytime.

Preliminary results show that the diurnal dynamics of of *P. minutus* and particularly of their nauplii is similar to the dynamics of larval rockfish. Similarly, a correlation was observed between the copepod *E. bungii* and pelagic tadpole snailfish. It is most likely that such correlations are the result of forager-consumer relationships.

S2-7012

Do mesozooplankton cause HNLC conditions in the high-latitude North Atlantic?

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The characteristics of oceanic 'high-nutrient, low-chlorophyll' (HNLC) regions are often attributed to iron-limitation, owing to the fundamental role that this element plays in phytoplankton growth and photosynthesis. The high-latitude North Atlantic (> 50°N) shows seasonal HNLC conditions that were recently ascribed to iron stress. However, an alternative hypothesis is that phytoplankton biomass in this region is under strong top-down control by micro- and mesozooplankton grazing. We quantified the potential of the dominant mesozooplanktonic grazers (calanoid copepods) to control phytoplankton productivity in the Iceland and Irminger Basin during spring and summer 2010. Net hauls for biomass estimations and experiments were sampled at 10 and 22 stations during spring and summer, respectively. Size-fractionated grazing rates of the mesozooplankton communities were estimated using allometric equations. Grazing rates of the predominant copepod, *Calanus* spp. were estimated using gut fluorescence analysis and bottle incubations. Incubation experiments were carried out under iron-clean conditions with artificial iron-addition treatments, and were supported by a series of dilution experiments to account for shifts in microzooplankton grazing pressure. Primary productivity was derived from dilution experiments and 14C measurements. Collectively, these data allow us to explore whether the North Atlantic phytoplankton stock is top-down or bottom-up controlled.

S2-7014

The pelagic food web in Cochin backwaters: The proliferation of micro-zooplankton

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The fact that Cochin backwaters sustain independent cycles of phytoplankton and meso-zooplankton is quite invoking and could be indicative of the existence of alternate food chains that increases the efficiency of the planktonic food web. The proliferation of microzooplankton could be one such pathway in transferring the energy from the nanoplankton (including bacteria) to mesozooplankton. The secondary production is mainly represented by mesozooplankton; especially copepods. These copepods fall in three distinct groups depending upon the feeding behavior (herbivore, omnivore, or carnivore). In case of zooplankton (micro- and meso-), high standing stocks (81.4±48.1 mg C m^{-3}; 88±125 mg C m^{-3}, respectively) were recorded during the pre-monsoon season. Copepods (Calanoids) formed the abundant group (75±18%) in the mesozooplankton community irrespective of seasons. The ratio of carbon content between phytoplankton and zooplankton (P:Z) was quite high (>100) during monsoon and post-monsoon seasons, but low during the pre-monsoon season (<5). A reduction in planktonic grazers during monsoon results in weak transfer of bacterial and primary carbon to higher trophic levels, leaving the basic food unconsumed. By the strong seasonality shown by microzooplankton, a large surplus of basic food remains unconsumed in the estuary during monsoon and post-monsoon seasons, which either settles out of the water column or is exported to the coastal sea. During periods of high freshwater input, the trophic food web of Cochin estuarine system is characterized by a substantial amount of unconsumed carbon in the form of primary producers due to the reduction in phytoplankton grazers.

S2-7026

Diet and prey selection of the chaetognath *Parasagitta friderici* in a eutrophic bay in Rio de Janeiro, Brazil

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This study describes the diet of the chaetognath *Parasagitta friderici*, and relates diet to prey availability in the highly eutrophic Guanabara Bay. Monthly samples of zooplankton were collected in triplicate from a fixed point located at central channel of the bay using a plankton net with 200 µm mesh. Zooplankton organisms were identified, counted and the gut contents of ~ 4500 individuals of *P. friderici* were identified to the lowest taxonomic level possible. Measurements of the size of *P. friderici* head and width of copepod prey from the guts contents and from the field were determined. The results showed that the dominant and frequent prey items in the diet of *P. friderici* were the copepods *Acartia tonsa*, *Oithona* spp. and family Paracalanidae. These copepods also occurred in high densities in the field suggesting that *P. friderici* feed according to prey availability. On the other hand, during the summer, *P. friderici* selected copepods species (*i.e. Clausocalanus furcatus*, *Calanoides carinatus*) from the adjacent coastal areas that did not occur in high densities in Guanabara Bay. The copepod *Temora turbinata* seemed to be avoided by *P. friderici* despite its high density in the field. *Parasagitta friderici* ingested copepod prey of wide spectrum of size but always smaller than 400 µm wide. Overall, *P. friderici* in the Guanabara Bay mostly feed according to prey availability, but may be unable to ingest wide copepods such as *T. turbinata*.

S2-7046

Effects of river discharge in the individual and community grazing rates of planktonic copepods in a seasonal upwelling system

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The coastal upwelling system of Central Chile (36ºS) is characterized by a strongly seasonal physical/chemical and biological regime, reflected in high productivity during spring/summer and lower productivity conditions during autumn/winter. This coastal area is also influenced by river discharge, which provides nutrients, silicates, dissolved, and particulate organic matter which can be channeled bottom up in the coastal food web. Here, we show the potential effects of river discharge on the autotrophic (nanoflagellates and diatoms) and heterotrophic (nanoflagellates, dinoflagellates, and ciliates) nano- and microplankton communities of river-influenced continental shelves, as well as the effect of such heterogeneity on the ingestion rates of planktonic copepods in those communities. We have selected two sampling stations, one located off the mouth of the river (Stn RV) and one located near the core of an upwelling center (Stn UW). On average, there were no significant differences in diatom biomass between sampling stations during spring or winter months, implying that the additional contribution of silicates from river runoff does not promote increasing diatom production at this site. However, the contribution in terms of biomass of microheterotrophs is more important in the river plume area, and is reflected in higher relative consumption of protozooplankton by copepods. Our results indicate that in coastal areas where the flux of dissolved organic matter from freshwater runoff may be significant, and the bacterial biomass and production is relatively high, the higher biomass of heterotrophic nanoflagellates can make autochthonous and allocthonous organic carbon available for zooplankton grazers and therefore also for upper trophic levels.

S2-7047

The relative importance of phototrophic, heterotrophic, and mixotrophic nanoflagellates in the microbial food web dynamic of a river-influenced coastal area

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Seasonal variations in contributions of phototrophic nanoflagellates (PNF) as primary producers and heterotrophic (HNF) and mixotrophic (MNF) nanoflagellates as major grazers of bacterioplankton were assessed during a three-year study in a highly productive river-influenced coastal upwelling area. Two stations were compared. Herein, 'mixotrophs' refers to nanoflagellates that combine phototrophy with phagotrophic heterotrophy. PNF abundance ranged from 6 to 411×10^3 cells m^{-2}, [QUESTION TO AUTHORS: are the units really cells m^{-2}? This seems quite low to me, given their large grazing impacts on bacteria] whereas HNF abundance fluctuated between 27 and 267×10^3 cells m^{-2}. In contrast, the abundance of MNF was usually low, with a maximum of $\sim7\times10^3$ cells m^{-2}. For MNF, ingestion rates were between 7.3 and 30.7 bacteria flagellate^{-1} h^{-1}, whereas HNF ingestion ranged from 2 to 7.5 bact flag^{-1} h^{-1}. However, since HNF dominated in terms of abundance, they were the dominant grazers on bacterioplankton populations. Estimates of grazing pressure for the microbial food web showed that MNF were capable of removing 1 to 51% BP d^{-1}, whereas HNF could control BP, eliminating from 24% BP d^{-1} up to more than 100% BP d^{-1} Given the area's relatively high nutrient condition, the elevated MNF biomass in the river plume, and the greater bacterivory impact from MNF in winter, it seems that light and energy/carbon limitation could be the main triggers for mixotrophy in river-influenced coastal upwelling areas. Although zooplankton may not use algal exudates, riverine DOC, and bacterial carbon directly, bacterivory by MNF and HNF could make autochthonous and allocthonous organic carbon available to zooplankton grazers and, therefore, to upper trophic levels.

S2-7053

Seasonal habitat utilization of *Calanus helgolandicus* in semi-enclosed marine lakes ("Veliko jezero", MPA „Mljet", South Adriatic Sea)

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Calanus helgolandicus is a key pelagic copepod in trophic food webs of the North Atlantic and surrounding ecosystems. Changes in the population size of this species have rarely been investigated in the Adriatic Sea. In this work, we examine the seasonal habitat utilization of *C. helgolandicus* in regards to environmental variations and predation pressure in the Marine reserve of Mljet Lake "Veliko jezero", a pristine ecosystem that offers a natural mesocosm to investigate ecology of zooplankton. In the marine lake "Veliko jezero", *C. helgolandicus* is one of the dominant species reaching abundances up to 249.6 ind/m^3 and contributing up to 15.86% of the total copepod abundance. We show that predation by jellyfish and chaetognaths act as major controls of the population size of *C. helgolandicus.* Pronounced seasonal vertical migration was observed. During the colder time of year, abundance is higher in upper layers. As temperature increase and upper layers become food depleted, *C. helgolandicus* migrate to concentrate in deeper layers, where they are faced with a trade-off between predatory risk and feeding opportunities. Such ecological interactions appear to be the main control on the population size of the species, although modifications in the functional responses might also occurs as consequence of food diet changes. Our results suggest large predator impact on zooplankton production in stratified marine environments.

S2-7082

Predatory impact and reproductive rate of *Acartiella sinensis*, an introduced predatory copepod in San Francisco Estuary

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San Francisco Estuary (SFE) is a highly invaded ecosystem and most of the zooplankton communities of the northern estuary are exotic species. *Acartiella sinensis*, presumed a predatory copepod based on morphology, was introduced from Asia in 1993, and yet little is known about its ecology. It is now one of the numerically dominant copepod species in SFE in summer (max=3,000 indiv m^{-3}). Predaceous consumers like *Acartiella* can significantly influence the distribution and composition of their zooplankton prey; *Acartiella* may therefore play an important role in regulating community structure. We determined *Acartiella* abundance, feeding and reproductive rates in an effort to understand its role in the SFE foodweb. We examined predation on several life stages of an abundant, co-occurring introduced copepod, *Limnoithona tetraspina*. Adult female *Acartiella* consumed *L. tetraspina* nauplii at an average rate of 6 nauplii $female^{-1}$ d^{-1} (=1.3% of the prey population consumed d^{-1}). This predation impact is expected to be higher when *Acartiella* is at peak abundances and when its other copepodite life stages are included. Predation on *L. tetraspina* copepodites and adults was low and variable, suggesting these life stages may be less susceptible to predation by *Acartiella*. Females produced an average of 14 eggs $female^{-1}$ d^{-1}, which is higher than two co-occurring calanoids (2-5 eggs $female^{-1}$ d^{-1}). *Acartiella* likely supplements its diet with other prey to support its higher reproductive (growth) rate. These observations have implications for energy transfer to higher trophic levels and point to a significant role of *Acartiella* in secondary production of the SFE.

S2-7093

Trophic interactions of jellyfish blooms with fisheries in the Yellow Sea

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Intense jellyfish blooms have occurred in the Yellow Sea in recent years, and may have been caused by environmental changes, such as increased water temperature, eutrophication, coastal modification, and overfishing. Therefore we addressed a number of questions about the trophic impact of jellyfish blooms on ecosystem structure and energy flows, using an Ecopath model covering the Yellow Sea during 2000-2001. We identified 19 ecologically important functional groups in the model, including 10 fish (7 single species and 3 multispecies), cephalopods, shrimps, crabs, benthos, jellyfish, zooplankton, phytoplankton and detritus. The mean trophic level of fishery catch in the Yellow Sea ecosystem for the period 2000-2001 was 3.26, and the trophic level of jellyfish was 3.14. Analysis of the trophic interactions indicated that jellyfish blooms had a negative impact on zooplanktivores, such as anchovy and other pelagic fishes, because of mutual competition and predation. Silver pomfret, although a predator and competitor of jellyfish, showed little effect on jellyfish, because of its low biomass. The pelagic pathway of the ecosystem may be disrupted at the initial stage of jellyfish blooms. Frequent jellyfish blooms may be a threat to the fisheries sustainability of the Yellow Sea.

S2-7119

How they survive: The growth and development of copepods in the food limited San Francisco Estuary

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Historically, the San Francisco Estuary (SFE) was characterized by low primary productivity resulting from a highly turbid system. In recent years phytoplankton biomass has declined as the result of grazing by an introduced clam and other anthropogenic influences. Coincident with the decline in productivity we observed declines in several species of calanoid copepods. These changes may have facilitated the introduction of the cyclopoid copepod *Limnoithona tetraspina,* which became the most abundant copepod. To investigate the potential impact of phytoplankton declines on copepods we measured the growth of the dominant copepods in the SFE. In spring-summer of 2006 and 2007 we measured *in situ* growth of the calanoid copepods *Eurytemora affinis, Pseudodiaptomus forbesi*, and *Acartiella sinensis* and the cyclopoid copepod *L. tetraspina.* Growth rates were determined through incubation experiments and measured as changes in carbon biomass or development (= molting). All three species of calanoid copepods had growth rates of less than 0.1 day^{-1}, much lower than their potential growth rates of about 0.3 day^{-1} under food saturated conditions. *L. tetraspina* had lower growth rates (0.03 day^{-1}) than all of the calanoid species. The decrease in the abundance of calanoid copepods may be due to food limitation, competition for food with *Limnoithona tetraspina*, and consumption of nauplii by the introduced clam. Despite their low growth rates, *L. tetraspina* remains highly abundant, suggesting low mortality. By determining how copepod production responds to changes in primary production we hope to acquire a better understanding of fluctuations in available carbon flowing to higher trophic levels, specifically fish.

S2-7130

The role of planktonic copepods in the diet of fishes from the subtropical Estuarine Complex of Paranaguá Bay, southern Brazil

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The subtropical Estuarine Complex of Paranaguá Bay is one of the least impacted large Brazilian coastal ecosystems, which support high biodiversity and highly exploited, abundant fish stocks. Many attributes that shape ecosystem structure, such as predator-prey interaction, fluxes of energy and nutrients, zooplankton and fish production, remain poorly understood, although this understanding is critical to support ecosystem-based fisheries management. In the present study, the role of planktonic copepods in the diet of the 31 most abundant ecosystem's fish species in four distinct habitats (oligohaline and polihaline estuarine zone, and estuarine and exposed beach) was assessed through the analysis of 6372 non-empty gut contents from June 2005 to April 2006. Planktonic copepods accounted for >50% of the biomass making up the diet of the six most abundant fish species: *Atherinella brasiliensis*, *Anchoa januaria*, *Harengula clupeola*, *Chloroscombrus chrysurus*, and juveniles of *Eucinostomus melanopterus* and *Centropomus parallelus*. Despite high richness (24 copepod species), only four calanoids, *Temora turbinata*, *Pseudodiaptomus richardi*, *Pseudodiaptomus acutus*, and *Acartia lilljeborgi*, which are among the most abundant zooplankton component in this system, made up >85% of the biomass of the consumed copepods. ANOVA revealed that habitat had a stronger effect than season on diet variability, and that this variation in predation pattern is likely due to the marked salinity-based spatial distribution of such copepods into the estuary. The present study showed that the most abundant nekton components preyed heavily on the dominant calanoids in the Paranaguá Bay Estuarine Complex, revealing their important role in the trophic structure of this ecosystem.

S2-7150

Mnemiopsis *vs.* Aurelia: The role of gelatinous top predators in the northern Baltic Sea food web

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The autumnal plankton communities of the northern Baltic Sea typically experience outbreaks of the moon jelly *Aurelia aurita*. At this time the zooplankton community consists of copepods and cladocerans that are preferred prey for *Aurelia*. The American comb jelly *Mnemiopsis leady* which recently intruded the southernmost parts of the Baltic Sea has not yet been found in the central and northern parts of the Baltic. To get first-hand information on the possible role of *M. leidyi* in the northern Baltic ecosystem, a mesocosm experiment was carried out on the SW coast of Finland. With this study we aimed to follow the effects of these two gelatinous top-predators (*Aurelia* and *Mnemiopsis*) on the lower food web. 12 units (100L tanks) were used for 4 treatments (controls + experimental units with jelly-addition) in 3 parallels. The tanks were filled with pre-screened seawater and a known community of zooplankton, boosted with inorganic nutrients, after which *Aurelia* or *Mnemiopsis* were added to the experimental units. During the experiment we followed the nutrient dynamics, abundances of organisms and production rates. The initial community represented a bloom situation with high Chl-*a* concentrations (approx 40 μg Chl-*a* L^{-1}). The high abundance of autotrophs resulted in rapid nutrient turnover rates and primary production rates during the first days. In the resulting nutrient-deficient situation the autotrophic growth ceased supporting the growth of bacterioplankton. During the experiment the heavy grazing of *Aurelia* and *Mnemiopsis* consumed up to 65% of the adult copepods.

S2-7177

Use of vital fluorochromes in microzooplankton grazing experiments

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Since the development of the dilution technique by Landy and Hassett (1982) the recognition of microzooplankton as key players in the dynamics of marine pelagic food webs has gained mounting evidence. One of the main advantages of the technique is that it provides an estimate of the whole microzooplankton community grazing impact on primary producers with relatively little manipulation. However, it confines microzooplankton into a black box approach in which the relevance of their distinct components is pooled together. Therefore, the development of new (more species-specific) techniques would be of great value in our understanding of microzooplankton dynamics. Here, we aimed at developing one technique for staining live algae via the utilization of vital fluorochromes, which not only permit cell viability but also allow easy identification into their predators. To identify potential negative effects of the stains on the algal growth, three different stains were initially applied to a total of nine algal species. None of the stains significantly affected growth. To evaluate the effect of staining on ingestion rates and the selectivity of the protozoans, we conducted bottle incubations of the dinoflagellates *Oxyrrhis marina* and *Gyrodinium dominans* with stained and unstained algae. The staining was not found to interfere with the feeding process. Finally, we conducted a series of dilution experiments, using the natural phytoplankton assemblage and also incorporating stained algae, to obtain a more precise estimation of the microzooplankton feeding rates under natural conditions.

S2-7194

Contribution of herbivory to the diet of the copepod *Temora longicornis* (Müller) in Belgian coastal waters

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The contribution of herbivory to the diet of *Temora longicornis* (Müller), an omnivorous calanoid copepod, and the degree of food limitation to its production were investigated in relation to phytoplankton availability in Belgian coastal waters. The gut fluorescence method was combined with egg production measurements to estimate herbivorous and total feeding, respectively. Diatoms were the main phytoplankton component during the sampling period and constituted, with the colonial haptophyte *Phaeocystis globosa,* the bulk of phytoplankton biomass during the spring bloom. High-performance liquid chromatography (HPLC) gut pigment analysis showed that diatoms were the main phytoplankton group ingested, whereas no evidence for ingestion of *P. globosa* and nanoflagellates was found. Further, our results showed higher phytoplankton ingestion by *T. longicornis* in spring, when small, chain-forming diatom species such as *Chaetoceros* spp. were abundant, than in summer, when larger species such as *Guinardia* spp. dominated the diatom community. We showed that *T. longicornis* could be regarded as mainly herbivorous during fall and winter, while during spring and summer they needed heterotrophic food to meet their energetic demands for egg production. The phytoplankton spring bloom, either during diatom dominance or during *P. globosa* dominance, did not enhance the contribution of herbivory to the diet. We argue that when *T. longicornis* carbon requirements for egg production increase the contribution of non-phytoplankton food sources (microzooplankton and/or detritus) to total carbon ingestion becomes more important. Except during the early spring diatom bloom of *Chaetoceros socialis*, the egg production rates never reached the production potential of this species, including during the *P. globosa* bloom. This suggests that *T. longicornis* egg production was limited not only by food quantity but also by food quality and that ingestion of non-phytoplankton food sources did not allow the females to compensate for food limitation.

S2-7233

Mesozooplankton grazing activity during a bloom dominated by *Pyrodinium bahamense var. compressum* in Sorsogon Bay, Philippines

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Studies have mostly dealt with physico-chemical interactions leading to the formation and decline of harmful algal blooms in the Philippines while information on the role of grazers and their ability to transfer toxins is limited. We have conducted grazing experiments in six stations in Sorsogon Bay to elucidate the possible roles of mesozooplankton during a bloom of *Pyrodinium bahamense var. compressum*. Gut Pigment Content (GPC), Gut Passage Time (GPT), Ingestion Rate (IR), and Paralytic Shellfish Toxins (PST) of *Lucifer hanseni* and two size classes, >200 and >00 µm, of Calanoida were measured using gut fluorescence method, 240 min starvation experiment, and pre-oxidation HPLC analysis, respectively. We found that the most prominent mesozooplankton grazer was the > 200 µm Calanoida (GPC 41±28 ng Chl-*a* µg body C^{-1}, GPT 130±71 min, IR 34±38 ng Chl-*a* µg body C^{-1} hr^{-1}, and PST 122 ng mg body C^{-1}). While the > 500 µm Calanoida was an intermediate grazer (GPC 19±31 ng chl*a* µg body C^{-1}, GPT 160±48 min, IR 9±17 ng chl *a* µg body $C^{-1}hr^{-1}$, and PST 12 ng mg body C^{-1}). And *L. hanseni* was classified as relatively the least significant mesozooplankton grazer (GPC 4±3 ng chl *a* µg body C^{-1}, GPT 190±149 min, IR 5±7 ng Chl-*a* µg body $C^{-1}hr^{-1}$, PST 12 ng mg body C^{-1}). Therefore, mesozooplankton grazers are shown to be vectors in transferring PST to higher trophic levels during the *P. bahamense* var. *compressum* bloom in Sorsogon Bay, and could be contributing to bloom decline through ingestion of vegetative cells.

S2-7251

Intraspecific differences in diel vertical migration in a Baltic Sea Mysis species (*Mysis salemaai, Mysidacea, Crustacea*), revealed by stable isotopes, C:N ratios and genetic markers

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As a trade-off between the benefits of occupying a habitat with favourable feeding/growth conditions and avoiding predators, many pelagic animals undertake diel vertical migrations (DVM) which also promotes a nutrient flux (directly and indirectly) between deep and shallow water. The Baltic Sea mysid shrimp *Mysis salemaai* (formerly known as *Mysis relicta*) exhibits this behaviour. However, studies in both the Baltic Sea and North American freshwater lakes show a two-layered night-time vertical distribution, with one portion of the population close to the bottom. This can reflect the presence of two groups of mysids with diverging migration patterns or can be the result of an unsynchronised DVM. Nitrogen and carbon isotopic compositions and C:N ratio in muscle tissue of pelagic and bottom dwelling mysids collected at night showed differences between groups; implying long term diet differences. The results of the isotopic composition can thus not be explained by unsynchronised DVM or inter-night variation in behaviour but rather by two groups of mysids with divergent diets and migration patterns. In addition to the differences found in nitrogen and carbon composition, the results are discussed in the light of complementary genetic data. This study suggest that bentho-pelagic coupling by mysids may be considerably lower than previously believed due to reduced vertical migration by a subset of the population.

S2-7270

Stimulating effects of bloom forming cyanobacteria on copepod reproduction and development

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As primary producers, cyanobacteria are important in many aquatic food webs. However, due to frequently observed production of toxins, they are often considered to have a negative effect on grazers. Every summer, the semi-enclosed brackish Baltic Sea is subjected to intensive blooms of filamentous cyanobacteria, with high contribution of the toxic cyanobacterium *Nodularia spumigena*. During a cyanobacterial bloom, we monitored seasonal development of phytoplankton, with particular emphasis on cyanobacteria, and copepod reproduction profile (egg production rate, egg viability, and RNA content in *Acartia* spp.), in a coastal area of the northern Baltic proper. This was complemented with a laboratory study, where copepods were exposed to feeding media with and without the cyanobacterium. The results suggest stimulating effects of cyanobacteria on copepod egg viability and early nauplial development, whereas total egg production is affected negatively. Possible causes and consequences of these effects will be discussed.

S2-7321

Plankton dynamics in a changing world. Compensatory dynamics and risks for ecological shifts

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Resolving to what extent interannual changes in marine ecosystems are driven by climate is crucial for both theoretical and management reasons in a changing world ocean. Here we investigate the relative importance of the strength of climate forcing on the dynamics of marine pelagic ecosystems. We used a high resolution data set that covers three decades of climate, hydrology and biological records. Our approach is based on Bayesian dynamic models and meta-analysis techniques to quantify the effect size of climate on: i) the timing of seasonal zooplankton development; ii) predator-prey interactions; and iii) compensatory dynamics and risks for phase shifts. Bayesian dynamic models allowed identifying the dynamic nature of the relationship between climate and the seasonal zooplankton development (SZD), and emphasize a non-stationary feature in plankton dynamics. Scales of influence of climate forcing on SZD were further detected and thereby we provide a segmentation of the climate time series into significant and non-significant phases. The significant phase was associated with a generally high temperature regime under which the probability of a rapid-turnover of species markedly improved. As a consequence, ecological predator-prey interactions shift, leading to reorganization of the plankton community. Both the predator-prey relationships, as well as the compensatory dynamics, evolve according to thresholds of external forcing (*e.g.* climate). Such thresholds suggest a predominant role of climate *vs*. ecological interactions as drivers of general patterns of plankton, and therefore help to understand coherent changes at population and community levels under such circumstances.

S2-7337

Copepod reproductive success in experimentally modified spring phytoplankton communities

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Global warming is modulating phytoplankton composition of the spring bloom in temperate aquatic environments by changing water mixing and nutrient conditions. Increases in dinoflagellates and decreases in diatoms have been observed in recent decades. According to previous research, we hypothesized that grazing copepods benefit from the increasing dinoflagellate: diatom ratio. We tested experimentally the reproductive output of the crustacean copepod *Eurytemora affinis* in five Baltic Sea phytoplankton spring communities dominated by different dinoflagellate or diatom species. Egg production (EP), egg hatching success and RNA: DNA ratio of the copepods was measured after a 4-d incubation period, preceded by a 5-d acclimation period. EP was highest on *Gymnodinium corollarium* -dinoflagellate dominated diet and lowest on *Skeletonema marinoi* -diatom dominated diet and on the natural spring community, but there were no differences in egg hatching success. The low EP and high RNA: DNA ratio on *Thalassiosira baltica* -diatom dominated diet indicated increased somatic maintenance and possible stress reaction caused by the diet, whereas both low EP and RNA: DNA ratios on *S. marinoi* -dominated diet might have been caused by rejection or feeding difficulties of the dominating species. The diet dominated by *Chaetoceros*-diatoms supported high EP rate as well as high RNA: DNA ratio. The results reject the hypothesis and address the need to explore the phytoplankton taxa on species level to reveal responses of copepods to future plankton communities. Both dinoflagellate and diatom dominated phytoplankton compositions can support high reproduction of this common Baltic grazer.

S3 Posters

S3-6434

Zooplankton in Iranian coastal waters (Oman Sea) during the Pre and Post-Monsoon period

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The Oman Sea is a strait that connects the Arabian Sea with the Strait of Hormuz, which then runs into the Persian Gulf. Tides and seasonal winds (Monsoon) have a major impact on environmental and ecological characteristics of the Oman Sea. Zooplankton surveys were conducted seasonally during May 2008 (Premonsoon) - December 2008 (Postmonsoon) at 10 stations in Iranian waters. Samples were collected by vertical tows using a 55µm mesh plankton net with a mouth opening of 0.4m diameter. Physical and chemical parameters such as temperature, salinity, dissolved oxygen and chlorophyll were measured with a CTDO. In this study 62 genera of 11 animal branches were identified. Copepoda (25%), Tintinnida (22%), Urochordata (6%), Mollusca (2%) were dominant groups. 22% of total copepoda were allocated to the genus *Oithona*. Distribution and accumulation of zooplankton in the Oman Sea were affected by the southwest Indian Ocean monsoon. Abundance was lowestbefore the monsoon (17%) and highest after the monsoon (83%).

S3-6900

Physiology and biology of Calanoid copepod eggs

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In Danish waters (56ºN) neritic copepod populations decline from dense summer populations to practically no pelagic individuals present during winter. Eggs produced during the productive season that reach the sediment, enter a resting stage wherein the embryogenesis is on a hold, and the resting eggs overwinters. Hence, an egg bank is present in the anoxic sediments with diapause eggs in the deeper part of the sediment and quiescent eggs in the surface of the sediment. A fraction of these eggs survive in this harsh sediment environment characterized by anoxia and sulphide up to approximately 70 years and remain viable when exposed for favorable environmental conditions. This phenomenon was mimicked under controlled conditions and egg physiology examined. Physiological tolerance of eggs to temperature, salinity, oxygen, and sulphide were provided in experimental set-ups. Eggs from *Acartia tonsa* (Dana) tolerate a large spectrum of environmental conditions. Eggs hatched, although slowly and inefficiently, even at 4ºC and the hatching success increased up to 24ºC. Eggs survive anoxia and even sulphide exposure, but a large fraction die after 2 months exposure. Eggs tolerate abrupt salinity decrease to zero and exhibited instant volume change when challenged with hypo- and hypersaline conditions. Part of the explanation is that subitaneous eggs enter arrested development during quiescence at adverse environmental conditions.

S3-6908 (*Cancelled*)

Preliminary results on the early life cycle of *Neocalanus plumchrus* and *Neocalanus flemingeri* in the Oyashio region, western north Pacific

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Neocalanus plumchrus and *N. flemingeri* are abundant and widely distributed copepods in the subarctic Pacific and are key species in the ecosystem. Although their life histories have been reported, early life histories of eggs and nauplius stages have not been studied yet. During the egg and nauplius stages it is difficult to identify them because of their undeveloped morphological characteristics. To overcome this problem we used a Taq Man probe, real-time PCR method to identify them genetically. *Neocalanus* species experience six nauplius stages and five copepodite stages during a year long life cycle. Previous studies suggested that early copepodids of both species appeared in the surface layer from March and May. To reveal the transition of distribution and stage compositon of nauplii, seasonal samplings were performed in the Oyashio region from October 2009 to July 2010. Preliminary result showed that the nauplii of *N. flemingeri* and *N. plumchrus* were vertically separated in October and January. All nauplius stages of *N. flemingeri* appeared in both months in upper 500m. The later stages of *N. flemingeri* were distributed in shallower depth. In contrast, *N. plumchrus* were mainly distributed below 500m. Unlike *N. flemingeri*, only NI to NIII stages appeared in both months. In addition, NIII appeared in a high ratio. In October, more than 70% of the nauplii were NIII. In January they increased to 94%. These results show that NIII *N. plumchrus* may have a dormancy phase.

S3-6930

Size distribution, sexual maturity and diet of the chaetognath *Flaccisagitta enflata* along the Pacific Coast and adjacent inland waters of the Philippines

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The size distribution, sexual maturity and diet of *Flaccisagitta enflata* along the Pacific Coast (Bicol Shelf) and Inland Waters (San Bernardino Strait, Ticao Pass, Sibuyan and Visayan Seas) of the Philippines are presented. *Flaccisagitta enflata* is an oceanic species which may serve as good indicator of influx of oceanic water into the neritic regions. It has been reported as the dominant chaetognath species in the Philippines. It is among the most dominant, second to *A. neglecta* in overall abundance, however, the only species observed to occur in the surveyed areas. Dramatic changed in density of this species was observed at stations located in the inland waters. Changes in size distribution and maturity were observed between the Pacific Coast and the Inland waters. The Visayan Sea samples comprised mostly immature and relatively small but mature individuals (5-10mm) while those collected in other inland waters (San Bernardino Strait, Ticao Pass and Sibuyan Sea) showed affinity in terms of size distribution and sexual maturity with that of the individuals collected in the Pacific Coast. Considered to be the most voracious cannibal of all chaetognath species, *F. enflata* feeds on fish larvae and other zooplankton. Gut content analyses showed that copepods (46%) and chaetognaths (40%) were the major prey items of this species. Fish larvae and fish eggs were likewise observed in the gut comprising 2-5% of the total prey items recorded. The observed percentages appeared low but nevertheless convey that it may have an important cumulative effect on fish larvae mortality. Nevertheless, the proportional abundance of fish eggs and fish larvae in the gut of *F. enflata* was lower relative to the other available prey. Other prey items constitute 10.2% of the overall abundance to include crustacean larvae, polychaete, larvaceans, salps, doliolum, echidoderm larvae, gastrula larvae, amphipod and radiolarians.

S3-6941

Ontogenetic and seasonal variations in lipid and fatty acid composition of the subarctic copepods *Neocalanus cristatus* and *Eucalanus bungii* in the Oyashio region, western North Pacific

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Lipid and fatty acid/alcohol compositions of *Neocalanus cristatus* and *Eucalanus bungii* from the western North Pacific were investigated. Adult copepods (female/male) and copepodite stages (C3-C5) were collected in March (pre-diatom bloom), May (after bloom) and December (winter) 2006 at various depths from 0 to 2000 m. Total lipid (% of dry wt.) and wax ester contents (% of total lipid) of *N. cristatus* showed a strong increase from C4 (13.5 and 32.8%, respectively) to C5 (53.6 and 84.4 %, respectively). In May, the total lipid and wax ester content of earlier stages was higher than that in March and December. In earlier stages major fatty acids were 16:0, 20:5 (n-3) and 22:6 (n-3), together with 16:0 and 16:1 (n-7) as dominant alcohols. Towards later stages the long-chain fatty acids and alcohols (20:1 and 22:1) became more prominent. The 16:4 (n-1) fatty acid, characteristic for diatoms, also increased in May, especially in earlier stages. These results suggest that active feeding on diatoms of earlier stages during the bloom season promotes effective accumulation of energy-rich lipids for dormancy of *N. cristatus*. In contrast, *E. bungii* accumulated substantial amounts of triacylglycerols. Total lipid and triacylglycerol content slightly increased towards the later stages. Major fatty acids of *E. bungii* were 16:0, 16:1 (n-7), 18:1 (n-9)/(n-7) and 20:5 (n-3). There was no evidence for ontogenetic or seasonal differences. This implies that the physiological mechanisms for dormancy and overwintering of *N. cristatus* and *E. bungii* may differ substantially.

S3-6958

Reproductive patterns in pelagic decapod shrimps from the northern Mid-Atlantic Ridge

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The deep sea is the largest aquatic environment on earth, but still belongs to the least studied areas. Low temperatures, high pressure and low food availability have forced a variety of evolutionary responses to the life history challenges for organisms living under such environmental conditions.

Decapod shrimps comprise a significant part of the pelagic biomass in the meso- and bathypelagic zone of the oceans. While the accumulated information on their distribution suggests that they play important roles in the vertical transport of organic matter, knowledge on life histories of deep-sea pelagic shrimps is limited.

We present reproductive patterns and population characteristics of three species of mesopelagic decapod shrimps (Caridea, Oplophoridea) sampled along the northern Mid-Atlantic Ridge from surface to near the bottom (0-3000m). Ovarian maturation, embryogenesis and fecundity are described for *Parapasiphae sulcatifrons*, *Acanthephyra pelagica* and *A. purpurea.*

Inter-specific differences in fecundity and egg size were found. The results demonstrate that closely related species may differ markedly in reproductive traits and that different reproductive strategies are present in co-occurring species in the deep-sea. Geographical variation was observed in population characteristics, indicating a possible link between deep-sea shrimps and the production in upper layers. The observed results are discussed in relation to vertical and geographical variations in environmental factors.

S3-6962

A high frequency time series of hydrography, nutrients, chlorophyll and *Calanus finmarchicus* life history at Weather Station Mike in the Norwegian Sea during 1997 and 1998

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During the years 1997 and 1998, hydrography, nutrients, chlorophyll and *Calanus finmarchicus* data were sampled at least weekly at Weather Station Mike in the eastern Norwegian Sea, down to more than 1000 m depth.

The data were analysed with respect to seasonal timing and vertical dynamic of water column stabilisation, phytoplankton bloom, nitrate consumption and ontogenetic migration, seasonal development and abundance of first, second and overwintering generation of *Calanus finmarchicus*.

Within years we observed how the formation of a shallow thermocline initiated the phytoplankton spring bloom, which led to a reduction in nitrate. The production of young copepodids belonging to the first generation of *C. finmarchicus* was temporarily closely linked to the spring bloom. The first generation reached CI 14-30 days after the adult females started to arrive at the surface, and developed into CV and adults within one month. Downward migration towards overwintering depth of CIV and CV commenced in late May already. The second generation followed approximately 3 months after the first generation.

Water column stabilisation, phytoplankton bloom and production of the first generation occurred 3-4 weeks later in 1997 than in 1998. No second generation was produced in 1997 and *C. finmarchicus* abundance was much lower this year. There was no difference in the timing of the arrival of the overwintering generation of *C. finmarchicus* at the surface between the two years, showing that the timing of the bloom is decisive for the dynamics of the new generation of *C. finmarchicus*, not the overwintering generation.

S3-6963

Life strategies of *Acartia* spp. populations in the Thau Lagoon

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To study the population dynamics of various *Acartia* species, zooplankton has been followed twice a month over three years (2008-2010) at a monitoring station under marine inflows in Thau lagoon (French Mediterranean coast) and at a shore station in 2010 to compare zooplankton biodiversity.

In Thau lagoon, several *Acartia* species coexist: *A. latisetosa, A. bifilosa*, *A. margalefi, Acartia clausi*, *A. discaudata* and a new comer *Paracartia grani,* never recorded before 1998 in this lagoon. While the first three species are rarely found at this station, *A. clausi* and *A. discaudata* can compose up to 78% of the zooplankton abundance, in February. Otherwise, *P. grani* can contribute up to 53% of the zooplankton abundance in August.

To better understand how these 3 congeners coexist, abundances, prosome length and egg production / hatching success experiments (at *in situ* temperature) were performed twice a month over a year.

Population dynamics show 2 perennial species as winter-spring species (*A. clausi* and *A. discaudata*) whereas *P. grani* is absent in the water column from February to April before a sudden apparition in May. Egg production combined with hatching success suggests that *A. clausi* and *P. grani* can produce quiescent eggs allowing their survival during unfavourable conditions and can provide a large pool of potential recruits in new favourable conditions.

Comparison with the shore station data was carried out to highlight if quiescent eggs are the only responsible factor for initiating/maintaining the population in the lagoon, or if some individuals are also advected from coastal waters.

S3-6970

Seasonal abundance of zooplankton south of Iceland in relation to environmental variables

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Seasonal variations in zooplankton abundance and composition, and the life history of the most common zooplankton species, were studied in relation to hydrography, chlorophyll *a* and nitrogen between February 1997 and March 1998. The sampling was carried out at two stations south of Iceland near the main spawning grounds of several commercially important fish species. Abundance of zooplankton was low during winter, peaked in June/July (~1.000.000 individuals m^{-2}) and remained relatively high until August (~600.000 individuals m^{-2}). A total of 63 species and taxonomic groups were identified in the samples. In general, copepods dominated the zooplankton (65%-95%) with *Temora longicornis, Oithona* spp. and *Calanus finmarchicus* being the most abundant species (~30%, 22%, 15% of the total zooplankton, respectively). Less important groups were *Evadne nordmanni* (~7%), *Pseudocalanus* spp. (~4%), copepod nauplii (~3%) and *Microcalanus* spp. (~3%). Redundancy analysis (RDA) was used to analyze seasonal differences in community structure, with months as categoral environmental variables. The community structure was significantly different among months (Monte Carlo test, P=0.002). The months explained 56% of the variation in community structure, while 34% could be explained by the environmental variables temperature, salinity, chlorophyll *a* and nitrogen. The RDA analysis further showed a very clear seasonal difference in community structure with the main gradient separating the winter community from the summer one. Seasonal cycles of the different zooplankton species were the main driving forces in this data set.

S3-6994

Eurytemora americana egg production and morphology in the Bahía Blanca estuary, Argentina

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The invader copepod *Eurytemora americana* develops a short planktonic pulse associated with the winter-spring diatom bloom in the Bahía Blanca estuary. This species presents two markedly distinct reproductive strategies depending on the temporal environmental conditions. The aim of this study was to analyze the *E. americana* energetic balance taking into account certain metabolic and reproductive aspects. Relationships among environmental variables, clutch size (CS), female size (prosome length-PL), egg size (ES) and egg morphology by SEM were studied during the 2007 population pulse. Kruskal-Wallis tests and Principal Components Analysis (PCA- Spearman´s correlation matrix) were used in order to analyze differences between means and relationships among variables. During the population growth period, smaller ES (89.14 – 94.48 µm, n=52), larger females and larger CS (114-101 eggs/sac) were observed. Conversely, in the population decline, an increase in ES (95.74 - 99.33µm, n=60) and a decrease in CS (40-5 eggs/sac) were registered. Very significant differences between ES (n=227, p=3.7742 E-18) were found along the population pulse. PCA showed clearly two different groups: CS-PL-salinity-chlorophyll *a* and ES-temperature. A negative correlation ($p < 0.05$ n = 227) between ES-CS and ES-PL, and a positive one ($p<0.05$ n=227) between ES and temperature were found. Morphological differences in the chorion between subitaneous and possible diapausal eggs were observed by SEM. During the population decline, *E. americana* would invest much of its energy in producing resting eggs showing in consequence, a reduction in its body mass and CS.

Poster - S3

S3-6995

Reproductive strategy and egg morphology of the copepod *Acartia tonsa* in a temperate estuary, Argentina

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The warm-water species *Acartia tonsa* has a wide distribution in estuarine areas, showing variation in morphological and physiological characteristics of its subitaneous and resting eggs. This work aims to evaluate the temporal variability in female size (PL-prosome length), egg production (EP), egg hatching success (HS) and egg morphology of *Acartia tonsa* in the Bahía Blanca estuary. Experimental incubations were conducted with field females simulating *in situ* environmental conditions. Non-parametric tests were used to analyze the relationships among all variables. Three morphological types of eggs (I, II, III) were described according to their spine length (SL) by optic microscopy and SEM (SL I: ≤2.55 µm; SL II: 3, 25-7.95 µm; SL III: 8.5 -16.15µm). Low egg production was recorded during the winter period (6.56 eggs. $f^{-1}.d^{-1}$) in which the presence of the three morphotypes was observed. However, the chorion morphology was independent of the hatching response, being the three morphological types, resting eggs with delayed hatching. Eggs differed significantly in diameter (D) and SL during winter from the eggs that were laid during summer. Negative correlations between SL - temperature (- 0.95) and between D-temperature (-0.75), were found. On the other hand, a positive correlation (0.74) between D (including spines) and PL was detected. During the summer period smaller females, higher egg production of subitaneous type I eggs (12.95 eggs. $f^{-1}.d^{-1}$) and higher hatching success, were observed. Temporal variability in the reproductive *A. tonsa* strategy, would allow it to remain in the plankton throughout the year.

S3-7001

The response of copepod grazing and reproduction to spring blooms of different species in the Southern Yellow Sea

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The responses of copepod grazing and reproduction to spring phytoplankton blooms in temperate shelf waters were studied in the Southern Yellow Sea in March - April, 2009. There were two different algae blooms found during the cruises. One was a diatom bloom dominated by *Detonula pumila* and *Guinardia delicatula*. Theother was a dinoflagellate bloom mainly composed of *Heterocapsa* spp. and *Prococentrum minimum*. The gut pigment contents indicated that the feeding activities of copepods were different in the different phytoplankton blooms. Although the concentrations of chlorophyll *a* of the dinoflagellate bloom were two times higher than that of the diatom bloom, the large copepods (body size >1000 µm) and medium size copepods (body size: 500-1000 µm) showed lower gut pigment contents during the dinoflagellate bloom. For small copepods (body size: 200-500 µm), there was no significant difference in the gut pigment contents between the species-different blooms. The egg production rates of the dominant copepod, *Calanus sinicus* were at the higher level recorded in the survey area, especially at the stations where the phytoplankton was blooming. Summarizing the results of the copepod grazing and reproduction, it is suggested that, although copepod grazing exhibited different responses to the species-different blooms, the spring bloom does enhance the reproduction of the copepods in the Southern Yellow Sea.

S3-7023

Lifecycle of the scyphozoan moon jellyfish *Aurelia aurita* in the Western Baltic Sea

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Scyphozoan jellyfish are seasonally abundant in coastal waters, but little is known about the distribution and factors controlling their population dynamics at different stages of their life cycle.

The Baltic Sea is a temperate, brackish water sea, characterized by a salinity gradient from the south-western part (25 PSU) to the north-eastern part (3 PSU). The most abundant scyphozoan jellyfish is the moon jelly *Aurelia aurita*, which reaches its salinity dependent distribution limit in the north-eastern part of the Baltic Sea. While in the central Baltic Sea only *A. aurita* medusae occur, polyps and medusae are present in the south-western Baltic Sea at salinities above 10 PSU. Few data exist about the life cycle of *A. aurit*a polyps and medusae in this area of the Baltic Sea.

In order to identify patterns in the occurrence of *A. aurita* in relation to environmental variables, we conducted a one year field study including net sampling for medusae and observations on polyp settling in the south-western Baltic Sea. In this study data of *A. aurita* medusa and polyps will be presented according to their temporal and spatial distribution in relation to environmental factors as well as to other jellyfish species. Furthermore, seasonal succession and favorable settling conditions for polyps were detected.

This data help to understand the life cycle of *A. aurita* in the south-western Baltic Sea as well as their population dynamics and the impact of global warming, eutrophication and constructions on mass occurrence events of scyphozoan medusae in the Baltic Sea.

S3-7027

The dead proportion of copepods in Jiaozhou Bay

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The dead proportions of *Calanus sinicus*, *Paracalanus parvus* and *Oithona similis* populations were investigated monthly on 12 stations in Jiaozhou Bay from December 2008 to November 2009 with the neutral red staining method. We found that annual variation of the dead proportion of the copepods was significantly different: *Calanus sinicus* appeared all through the year, with extremely low abundance in summer. The dead proportion of females was less than 5%, the death proportion of copepodids was less than 15.4%. The proportion of dead females was high in April and November, when seawater temperature was not exceeding its thermal limits. It is likely that their death was caused by unfavorable temperature. Death of females occurred most possibly as reproduction “cost”. The mean level of the dead proportion of *Paracalanus parvus* varied between 3.8% and 12.4% for females, 2.6-11.4% for males, and 4.9-14.1% for copepodids all through the year. The dead proportion of *P .parvus* was significantly higher in summer. The mean level of the dead proportion of *Oithona similis* varied between 0.7% and 7.6% for the females, 5.5-33.3% for males, and 2.9-8.7% for copepodids. All through the year, the deaths of males were 11 times greater than those of females. It is unlikely that this difference can be attributed simply to the shorter physiological longevity of males. Comparing with other studies, our study showed that the deaths of these copepods were not significantly higher than in other environments. It is suggested that environments like Jiaozhou Bay are suitable for living despite heavy influence by human activities.

S3-7041

Nyctiphanes simplex embryogenesis synchronization with female molting and gonadal cycles (Crustacea: Euphausiacea) in the Gulf of California

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The embryology of euphausiids has been studied only in temperate and polar broadcast spawning krill species, which apparently have highly synchronized gonad and molt cycles. In the past it has been assumed that these species have gonad development, interbrood period, brood size and proportion of the gonad spawned similar to sac-spawning krill species. This study describes histologically the embryogenesis of the sac-spawning euphausiid *Nyctiphanes simplex* and explores its temporal association with the gonad development and molt cycle. Swarms of euphausiids were collected in the Gulf of California during July 2007 and March 2010 and incubated shipboard. 115 ovigerous females in different stages of embryonic and gonadal development were preserved, and later processed and stained with various histological techniques. We describe embryogenesis of one cell, multiple cells, morula, blastula, gastrula and early or late limb bud and twiching stages. Larvae hatch as nauplius (N) and develop later as pseudo-metanauplius (PMN). The larvae are released from the ovigerous sac as metanauplii (MN). Ovigerous females with embryos in cell division stage have gonads in the multiplication stage, from nauplius stage some females have pre-vitellogenesis gonad and only females with MN occasionally have gonads in vitellogenesis. The gonad maturity occurs only after completing the release of the embryos from the ovigerous sac. Females with ovigerous sac were invariably in intermolt stage suggesting a precise synchronization among processes of molting, gonad development and the release of the embryos to produce consecutive broods. Lipid storages decrease throughout the embryonic development until the first feeding stage (calyptopis 1).

S3-7043

Comparative phylogeography and connectivity of zooplankton based on DNA barcodes

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A growing database of DNA barcodes for marine zooplankton is providing the key for decoding species diversity by linking species names, morphology, images, and DNA sequence variation. A taxonomically-comprehensive barcode database for the zooplankton will facilitate rapid analysis of species diversity and distribution in the pelagic community, including identification of known species, classification of novel barcodes, and estimation of numbers of species present. DNA barcodes are also useful for comparisons among ocean regions and realms, analysis of large spatial scale population connectivity, global-scale phylogeography, and discovery of cryptic species. Use of a standard measure of connectivity, such as DNA sequence divergence of the barcode region, allows comparisons of patterns of connectivity in light of phylogenetic constraints, life history and behavior, and other ecological and evolutionary conditions and processes. Next-generation high-throughput sequencing is making such approaches accurate, comprehensive, and cost-effective. In light of the pivotal position of zooplankton in ocean food webs, their usefulness as rapid responders to environmental change, and the increasing scarcity of taxonomists, DNA barcodes offer many advantages for analysis of global patterns of pelagic biodiversity, phylogeography, and connectivity.

S3-7055

Overlapping size ranges of *Calanus* spp. off the Canadian coast: Impacts on oceanographic surveys

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Many marine sibling species are distinguished by subtle morphological characters. For *Calanus* spp., these characters are only observed at the late copepodite/adult stages and microscopic discrimination is fastidious. In routine identification, oceanographers mostly distinguish *C. finmarcicus*, *C. glacialis,* and *C. hyperboreus* on the basis of allegedly non-overlapping prosome length ranges. We re-appraised such species diagnosis for the CV stage by coupling prosome length data with molecular identification. We genetically identified species (mtDNA, 16S gene) for 1160 individuals collected over two years from 16 stations over two years off the Canadian coast from the Arctic to the Atlantic. We observed spatial but no intra- or inter-annual variation in average prosome length of the different species. Overlap of prosome length of the three *Calanus* spp. was common. It was more frequent between *C. finmarchicus* and *C. glacialis* and restrained to the Estuary / Gulf of St. Lawrence between *C. glacialis* and *C. hyperboreus*. We used discriminant analysis to redefine prosome length criteria in order to minimize error in species identification. In the St. Lawrence Estuary, abundance estimates were affected mostly for *C. glacialis*. From 1997 to 2007, this species abundance was underestimated by 7 to 64%.

S3-7056

Hybridization of *Calanus finmarchicus* and *Calanus glacialis* off the Canadian coast

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C. finmarchicus and *C. glacialis* occur in sympatry in the North Atlantic Ocean. Preliminary data on *C. finmarchicus* population genetics revealed the presence of hybrids with *C. glacialis* in the St. Lawrence Estuary. We investigated the spatial distribution of hybrids by characterizing 720 individuals with one mitochondrial (16S) and 10 nuclear markers (microsatellites) at 12 stations off the Arctic and Atlantic Canadian coast. Considering both type of markers, we found a wide range of hybridization level and as many as 40% of hybrids within one station. Seasonal variations in species and hybrid frequencies were also investigated in relation to fitness. Mature females with prosome length encompassing both species ranges were sampled from March to August in the St. Lawrence Estuary and hybrid status was related to egg number, morphology, and survival. Recent results will be discussed in relation with common knowledge that *C. finmarchicus* and *C. glacialis* reproduce in spring and summer, respectively.

S3-7069

Latitudinal gradients in copepod community composition in the Northern California Current and S. Gulf of Alaska during years of varying ocean conditions

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During summer from 1998 to present, zooplankton have been sampled by various research programs from the central California Current north to the southern Gulf of Alaska, a distance of 2000 km. Comparisons among these programs are of interest because there is a strong latitudinal gradient in ocean conditions among regions, particularly in the strength of coastal upwelling and length of the upwelling season. Off California and southern Oregon upwelling is strong and occurs over most months of the year, but is less strong and highly seasonal off central and northern Oregon, relatively weak off Washington and Vancouver Island, and completely lacking off northern British Columbia and southeast Alaska. Due to these latitudinal gradients in hydrography, we expect to identify faunal boundary regions. Sampling intensity was highest during the summers of 2000 and 2002, so these years serve as our focal comparisons. Sufficient sampling was also carried out during the 1998 El Niño event and the warmer year of 2003 to allow for comparison of differences in climatic forcing and ecosystem response among regions. We examine copepod species density, species richness, distribution, and community composition and relate these to temperature, salinity, mixed layer depth, water column stratification, and chlorophyll *a* concentration. We use multivariate ordination and cluster analysis to describe spatial and interannual relationships between copepods and differences in physical conditions as well as responses to different climatic conditions among contrasting years.

S3-7087

Population dynamic of mysid community and its key role for nursery function in a temperate estuary

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The Guadalquivir estuary and adjacent marine habitats make up the main nursery ground for young stages of marine species caught by the fleet of the Gulf of Cadiz. It is a well-mixed temperate estuary with a gradual horizontal change in salinity and a clear seasonal trend in water temperature. Species *Mesopodopsis slabberi, Neomysis integer* and *Rhopalophthalmus tartessicus* make up mysid community which means over 80% of total macrofauna biomass in the estuary. Understanding the abiotic and biotic mechanisms determining mysid spatio-temporal distributions is therefore important to comprehend the general processes structuring estuarine communities and the estuary nursery function. Species life history, population structure, secondary production and community spatio-temporal dynamic were unravelled combining a long term 12 years monthly monitoring with a 2 years monthly sampling program. Results show high seasonal temporal distribution for the three species, showing density peaks (23,3 and 6 mg/m^3, respectively) in spring and summer and coastward migration out the estuary at winter. Despite being euryhaline, the three species of mysids were unevenly distributed along the saline gradient, the salinity being the environmental variable which best explained structure changes in the estuarine mysid assemblage. Inter- and intra-specific euryhalinity differences both in prey and predators seem to determine the entire spatial estuarine community distribution. High secondary production (P/B rates of 38.2, 10.3 and 10.7, respectively) confirm their key role in the food web, and the spatial/seasonal coincidence of their maximal density with that of their predators suggests food availability as a key factor in the estuarine nursery function.

S3-7090

Selective impact of the predatory cladoceran *Cercopagis pengoi* on zooplankton community in the Gulf of Riga (Baltic Sea)

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The predatory cladoceran *Cercopagis pengoi* invaded the Baltic Sea in the early 1990s. Since then, significant changes observed in the native zooplankton were attributed to this alien species. We have studied feeding habits of *Cercopagis pengoi* in laboratory conditions by using both newly born first instar individuals as well as older parthenogenetic females as predators. We offered them various single and mixed prey in densities that correspond to the natural conditions in the Gulf of Riga. It appeared that *C. pengoi* is an aggressive predator and able to consume any provided prey. Probably because of size limits, only newly born youngs were unable to consume adult copepods. Copepod *nauplii* and the native small-sized cladoceran *Bosmina* spp. were, in case available, the major and preferred prey for *C. pengoi*. In general higher prey density resulted in elevated consumption rates. This provides additional evidence on quantitative consequences on invasion of predatory cladocerans and allows estimation of the associated potential impact to upper trophic levels.

S3-7121

Life cycle and seasonal vertical distribution of copepods in oceanic subarctic waters north of Iceland

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Abundance and seasonal vertical migrations of dominant zooplankters were studied in the oceanic subarctic Iceland Sea as based on data collected on 6 cruises covering all seasons of the year from 2006 to 2008. Seven taxa constituted >98% of copepod biomass, *Calanus hyperboreus, C. finmarchicus, Metridia longa, Euchaeta norvegica, E. glacialis, Oithona* spp. and *Pseudocalanus* spp. A seasonal migration pattern was evident in most of these species. Due to their high biomass, *C. finmarchicus* and *C. hyperboreus* are key species in the system. *C. finmarchicus* overwintered at ~200-600 m depth at very low temperatures (~0°C). The animals had ascended to the surface layers by early May where reproduction and growth took place, mainly in the upper 50m of the water column. After August the animals then returned to deep waters for overwintering. The data on stage structure thus indicate a one year life cycle for *C. finmarchicus*. *C. hyperboreus* also stayed deep during winter (~200-1000m). However, in contrast with *C. finmarchicus,* the animals reproduced at depth during winter, and the offspring from the winter reproduction may not have developed beyond stage 3 during the first summer. Thus the seasonal stage structure suggests that *C. hyperboreus* species may have a 2-3 year life cycle. The life cycle and seasonal vertical distribution of the other biomass dominant copepods (*Metridia longa, E. norvegica, E. glacialis, Oithona* spp. and *Pseudocalanus* spp.) is compared and contrasted with these two species.

S3-7165

Understanding the importance of the bottom cold water mass as an over-summering refuge for *Euphausia pacifica* in the Yellow Sea

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The bottom cold water mass (YSBCM: ≤10°C) is a unique physical feature of the Yellow Sea. It forms through winter cooling and mixing and it is persistently observed in the deep central region during summer. *Euphausia pacifica*, known as a key species in the Yellow Sea should use the YSBCM as a refuge to survive through the hot summer (>25°C in surface) because their high limited tolerance is 15°C. However, no solid evidence was reported yet to prove it. Therefore, we investigated their horizontal and vertical distribution and feeding ecology during spring (YSBCM was not formed) *vs.* summer (YSBCM was well developed) in 2010. In spring, eggs predominated in all stations, but the early larval stage (nauplii) and gravid females (≥2cm TL) were concentrated in the coastal region with an active diel vertical migration. In summer, the abundance of larvae (calyptopis and furcilia stage) with a few number of eggs increased in the coastal region. Juveniles and small adults (≈1cm TL) were concentrated in the YSBCM of the central region. According to detailed profiles of the dietary lipid biomarkers and gut content analysis, *E. pacifica* adults mainly fed on diatoms/dinoflagellates during the spring phytoplankton bloom, while they fed on microzooplankton such as protozoa during the summer. These results suggest that *E. pacifica* may not only utilize the YSBCM as an over-summering site but also switch their food sources to survive through the hot summer.

S3-7166

Phase transitions of wax esters adjust buoyancy in diapausing *Calanoides acutus*

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Calanoid copepods inhabiting high latitude ecosystems contain exceptionally high amounts of lipid and overwinter at great depths in the world's oceans in diapause, a state analagous to hibernation. During diapause, copepods are thought to maintain a state of neutral buoyancy to reduce swimming activity and minimise energy expenditure. However, the exact mechanism(s) of buoyancy regulation has remained elusive. Here we study the composition and biophysical properties wax esters extracted from the Antarctic copepod, *Calanoides acutus* to explore if these factors adjust buoyancy in diapausing copepods. Levels of lipid in the copepods were correlated with depth, with deeper animals containing higher amounts of lipid. An unsaturation index was used to determine the proportions of polyunsaturated wax esters in the oil sac of the copepods. We found that the proportion of polyunsaturated wax ester in copepods that had descended to depth was always close to 50% and attributable to high amounts of the diatom biomarker fatty acid 20:5 (n-3) contained in these storage lipids. High pressure differential scanning calorimetry (HP-DSC) indicated that wax esters with such levels of unsaturation exhibited unusual properties, changing from a liquid to a solid phase at pressures and temperatures found below 500 m in the ocean. The dense, solid wax esters reduce the overall buoyancy of the lipid rich copepods at depth and help facilitate neutral buoyancy. We propose that the composition of wax esters is a key factor in buoyancy control in these organisms during diapause.

S3-7167

Seasonal lipid dynamics and diapause of *Calanus finmarchicus* in a fjordic environment

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The lipid content and composition was determined in individual stage V *Calanus finmarchicus* over an 18 month period in Loch Etive, a fjordic environment on the west coast of Scotland. The results will be discussed in terms of lipid utilisation during overwintering, and how changes in lipid composition are potentially linked to the termination of diapause.

S3-7168

Pressure induced homeoviscous adaptation of cellular membranes in diapausing *Calanoides acutus*

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We studied the fatty acid composition of polar lipids in *Calanoides acutus*, the dominant copepod in the Southern Ocean. Copepods were collected from depth horizons ranging from the surface down to 1000 m. Polar lipids, which are major constituents of cell membranes, were dominated by the essential fatty acid 22:6 (n-3), a biomarker for flagellated microplankton. At all stations the proportions of 22:6 (n-3) in the membrane fatty acids of *C. acutus* increased with linearly depth indicating homeoviscous adaptation (HVA). This finding suggests a specific function for 22:6 (n-3) in the regulation of membrane fluidity in response to increased hydrostatic pressure during the diapause life phase of *C. acutus*.

S3-7207

Phenology of reproduction of two calanoid copepods in the Arctic: Life history adaptation and predictability of sea ice break-up

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A potential future scenario in the marine Arctic involves a continued decrease in the summer sea ice extent, possibly with the whole of the Arctic Ocean being ice free in summer within the next decades. It has been hypothesised that one consequence of this change could be the shift in northward distribution of the Atlantic calanoid copepod species *Calanus finmarchicus*, which might outcompete its endemic Arctic sibling species *C. glacialis*. The two species coexist in some parts of the Arctic, but *C. glacialis* dominates. The challenge, in order to be able to predict whether this species shift would happen, lies in knowing the exact "weak spot" in the present life cycles of the two, relative to the new environmental scenario. In order to evaluate what this could be, it is necessary to place the two species, with their respective life cycles in the "new" environment. In the present study, the phenology of reproduction of the two *Calanus* species is reviewed, based on published information on reproduction in different areas of the Arctic. Time of first egg production is determined based on back-calculations from stage distribution combined with known temperature dependent development times. This will be discussed in the context of predictability of sea ice break-up and the consequent predictability in food availability for the developing generations of the two species.

S3-7219

Influence of the mesoscale structure off Baja California on the diversity and abundance of the larval fish assemblages

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The influence of cyclonic and anti-cyclonic eddies on the distribution of larval fish assemblages during winter and summer 2000 was analyzed. Statistical analyses showed that the general distribution patterns can be explained by the latitudinal temperature gradient and the ocean-coast gradient of the mixed layer depth. We estimate the geostrophic flow from CTD casts and compared the distribution and abundance of the ichthyoplankton assemblages by development stage (including eggs and preflexion, flexion and postflexion larvae). Although on a larger scale (the whole study area) the distribution and abundance of the fish larvae is conditioned by the biogeographic (temperate, subtropical and tropical) as well as the adult habitat affinities (coastal and ocean), on a smaller scale eddies explain how the fish larval assemblages are maintained or modified trough their planktonic life. The fish larvae composition showed the presence of: a northern region composed by temperate species (*Merluccius productus, Diogenichthys atlanticus* and *Nannobrachium ritteri*); a southern region composed by tropical and subtropical species (*Synodus lucioceps, Hygophum atratum, Nannobrachium idostigma* and *Cyclothone acclinidens*); and a transition region characterized by a species combination of both assemblages. This regionalization corresponds to the presence of two eddies in the central region of the study area. The ichthyoplankton distribution patterns showed that cyclonic and anticyclonic eddies represented dispersion mechanisms for eggs and larvae of some species such as *M. productus* and *Leuroglossus stilbius*, while for some others such as *S. lucioceps* and *H. atratum* they represented barriers that limited their distribution towards the north.

S3-7245

Occurrence of copepod carcasses on the inner shelf off Ubatuba (Southeastern Brazil)

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The neutral red staining method was applied to study the prevalence of copepod carcasses in the Ubatuba region, Southeastern Brazil, from November 2006 to November 2007. We performed monthly sampling on a fixed station located at the 40-m isobath, 18 miles offshore (“outer station”), and visited an additional station at the Boqueirão Channel (“inner station”) on several occasions during January-February 2007. On average, 30.9±14.3% of the copepod population appeared dead, a figure similar to other observations from estuarine and coastal environments. Carcass proportions decreased from the inner to the outer station. Highest and lowest proportions of dead animals were registered in winter and summer, respectively. Numbers of dead copepods did not differ between horizontal and vertical tows. Carcass and live copepod abundances were significantly correlated. The results confirm that neutral red staining is a useful tool in zooplankton ecology studies. The detection of relatively high percentages of planktonic copepod carcasses off Ubatuba indicates that non-consumptive mortality (*i.e.*, mortality due to food limitation, parasites or diseases, among other factors) may have a significant, year-round impact in the metabolism of coastal ecosystems.

S3-7256

The influence of hydrodynamic processes on zooplankton transport and distributions in the North western Mediterranean Sea estimated from a lagrangian model. Application to *Pelagia noctiluca*

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A Lagrangian module has been developed and coupled with the 3D circulation model 'Symphonie' to study the influence of hydrodynamic processes on zooplankton transport and distributions in the North Western Mediterranean sea. We simulate the trajectories of passive and vertically migrating zooplankton within in a domain extends between longitude 1.75°W and 10.90°E and latitude 38.28°N and 5.61°N. In order to classify different zones of the NWM as aggregative or dispersive, we divided the model domain into 9 sectors. The model is firstly used in forward procedures to study teleconnectivity between different regions of the NWM Sea. The individuals are released from March to October from different places of the NWM and tracked for 40 days either as passive zooplankton or with a simple diel vertical migrations (DVM) pattern. Then, the model is used in backward procedure to study the origin of organisms drifted to the coastal line all around the NWM Sea. This backward procedure is particularly interesting to investigate the patterns of distribution of the jellyfish *Pelagia noctiluca* from areas where coastal jellyfish invasion have been observed, *i.e.* on the French Riviera, the Gulf of Lions and the Catalan and Balearics seas. The simulations offer a tool to suggest potential pathways of jellyfish transports in the NWM Sea.

S3-7259

Modelling spatial distributions of zooplankton life stages influenced by mesoscale circulation in the North Western Mediterranean Sea during the year 2001

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The seasonal spatial distributions of *Centropages typicus* in the north western Mediterranean Sea is simulated with zooplankton population model coupled to a 3D physical-biogeochemical model of the North Western Mediterranean Sea ecosystem. The spatial distribution patterns of the different life-stages are analyzed for three different dates presenting the population structure at the onset of its predominant seasonal occurrence (April 3rd) and its end (June 25th), and in winter (December 15th) in relation to the hydrodynamical structures, their productivity and the presence of predators. The general pattern depicts a development enhanced by the Rhone River plume in February. In June, the population is spread all over the shelf and offshore areas but presenting variable concentrations related to productive hydrodynamical structures. In winter, the population dominated by older life-stages (copepodites) is found near the coast and within the Rhone River plume sustaining remaining individuals. Offshore, the vertical distribution denotes the presence of overwintering individual along the northern current front in the Ligurian Sea and off the Gulf of Lions shelf.

S4 Posters

S4-6996

Effects of water source change on zooplankton in aquaculture ponds

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We studied the effect of changes in water source on the abundance, biomass and structure of zooplankton in three aquaculture ponds stocked with common carp. The water sources used in the first year were surface waters from a reservoir pond, a small nearby stream, and two small open wells. During the second year a new source was introduced, deep tube-well. Throughout a two year study period, eleven abiotic parameters (temperature, transparency, oxygen concentration and oxygen saturation, electrical conductivity, pH, $KMnO_4$ oxidation, phosphates, ammonia nitrogen, water hardness and chlorophyll *a*), zooplankton and fish were monitored bi-weekly from May to October. Most of the investigated water parameters, except temperature, transparency and $KMnO_4$ oxidation, were significantly different between water sources. The pooled data for all ponds showed a significant change in the abundance and biomass of zooplankton, between water sources. The diversity and abundance of Rotifers and Cladocerans have dramatically decreased, during the second year, while Copepods remained consistent. Correlations between zooplankton and fish and between most of the abiotic parameters were statistically significant. Our results suggest that Copepods are more tolerant to changes of water characteristics in freshwater ecosystems than the rest of the zooplankton groups.

S4-7141

Copepod assemblage dynamics in a tropical estuary

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This study examined the seasonal variations in the dynamics of Copepoda assemblages in Macaé River estuary, a eutrophic tropical estuary in southeastern Brazil. Samplings were conducted in four sites covering the coast, estuary and river environments in four periods (two dry and two rainy seasons) throughout one year. In each period, samplings were done during four tidal cycles in spring tides, over 48 hours: four ebb and four flood tides. Samples were collected by horizontal hauls using a cylindrical-conical net (200 µm net mesh). Influences of salinity, temperature, chlorophyll *a* concentration, rainfall, daylight and tides on the assemblages were tested. The formation of copepod assemblages in the estuarine region showed variation over time, according mainly to rainfall in the region: during periods of higher rainfall two assemblages were formed, while during the drought period only one assemblage was formed in the region. The dominant copepod species in the region were *Acartia lilljeborgi*, *Oithona hebes*, *Parvocalanus crassirostris* and *Paracalanus quasimodo*. Copepod densities were inversely correlated with the chlorophyll *a* concentrations. This top-down effect was clearer in the drought period, which presented a high number of Ctenophora and also the lowest copepod densities and the highest chlorophyll *a* concentrations observed throughout the study period. Tidal cycle and daylight did not influence the copepod dynamics. In the estuarine region, synergism among factors such as predation, rainfall and eutrophication influenced the composition and distribution of copepod assemblages.

S4-7178

Seasonal adaptations of *Daphnia pulicaria* swimming behaviour: The effect of water temperature

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Daphnia swimming behaviour is controlled by a variety of external factors, including light, presence of food and predators. Temperature represents a key driver in the dynamics of *Daphnia* populations, as well as on their motion. In this work we investigated the behavioural adaptations of adult *D. pulicaria* to two different temperatures, representative of the mean winter (3°C) and summer (22°C) temperatures to which these organisms are exposed. Video observations were conducted both in the presence and in the absence of light to investigate possible day/night modifications in the motion strategy. Analyses of mean speed, velocity power spectral density and trajectory fractal dimension point out specific adaptations that allow *D. pulicaria* to successfully adjust to the changing conditions of the environment. Independently of the light conditions, in cold waters *D. pulicaria* swim almost vertically with defined motional frequencies, likely to increase the encounter with food items diluted in the fluid. A similar behaviour is displayed by the animals at summertime temperatures in the presence of light; however, in this case the vertical swimming is coupled with the absence of peaks in the power spectra and might be exploited to avoid predators. By contrast, at 22°C in dark conditions *D. pulicaria* move horizontally with lateral motions to take advantage of possible patches of phytoplankton. This information sheds new light into the complex and dynamic adaptations of *D. pulicaria* in response to external stimuli.

S4-7209

Tidal and seasonal changes in the mesozooplankton community in a highly turbid and mixed estuary (Bahía Blanca, Argentina)

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The role of seasonal and semidiurnal tidal cycles on the mesozooplankton dynamics was investigated in the inner zone of the Bahía Blanca Estuary, Argentina. Hydrological data and mesozooplankton samples were obtained bimonthly from December 2004 to April 2006, during 14-h tidal cycles. Precipitation and wind data were obtained from a meteorological station. Sea level was recorded with a tide gauge. The mesozooplankton community was represented by 33 taxa. The taxa richness was higher near the bottom, where the contribution of benthic forms was more relevant. The highest abundances were observed during summer (>5500 ind. m^{-3}) and the lowest during winter (<70 ind. m^{-3}). The mesozooplankton community was largely dominated by *Acartia tonsa* and *Eurytemora americana*. Due to their numerical importance, these copepods directed the tendency of the total mesozooplankton abundance. Multivariate analysis revealed significant seasonal differences in the mesozooplankton community structure, especially in terms of number of organisms. Seasonal differences in composition and abundance are well explained by the natural change of abiotic and biotic conditions, although temperature played a key role in structuring the mesozooplankton community. Short-term temporal variations were also attributed to semidiurnal tidal cycles. Zooplankton reached significantly higher abundances during the ebb tide, suggesting that local hydrological conditions play a dominant role in driving spatial variations. The results suggest that, depending on the time scale, different abiotic and biotic factors can control mesozooplankton community structure in the Bahía Blanca estuary and other temperate, turbid and mixed systems.

S5 Posters

S5-6431

Trends in the distribution and diversity of tintinnids in Iranian waters of the Oman Sea

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Tintinnid ciliates are planktonic grazers of nanoplankton. They have a lorica (or shell) into which the ciliate cell can withdraw. The distribution and species composition of tintinnids was investigated in Iranian waters of the Oman Sea from Fort of Hormoz to Pasabandar.

Tintinnid surveys were conducted over two seasons, during May 2007 (pre-monsoon) and December 2007 (post-monsoon). Samples were collected from 40 stations by vertical tows with a 55-µm mesh closing net, with a mouth opening of 0.4m diameter. Sampling depth ranged from 5 to 50m.

A total of 16 genera of tintinnids from 10 families were identified. These families are the Tintinnidae (4 genera), Xystonellidae (2 genera), Ptychocylidae (2 genera), Rhabdonellidae (2 genera), and a single genus each belonging to the Tintinnidiidae, Codonellidae, Epiplocylididae, Dictyocystidae, Metacylididae and Ascampbeliellidae. Ciliates from the genera *Tintinnopsis, Codonellopsis, Leprotintinnus, Rhabdonella, Dictyocysta, Eutintinnus and Xystonella* comprised about 94% of the total tintinnid abundance. Shannon's diversity index showed high abundance and diversity during the cool season (post-monsoon) and lower abundances in spring and summer (pre-monsoon).

S5-6911

Production of *Penilia avirostris* (Cladocera, Ctenopoda) off Ubatuba, Brazil

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I studied the temporal distribution of biomass and secondary production of the marine cladoceran *Penilia avirostris*, off the southeastern coast of Brazil, for three consecutive years (July 2005 through June 2008). Samples were collected monthly at a fixed neritic station (23°36´S 44°58´W) located on the 40 m isobath. *Penilia avirostris* individuals and its embryos were counted, measured and classified into size categories. Biomass was derived from a length-weight regression, and growth rates (considering growth increments of 50 µm) were estimated for each size class. Development time was calculated using a second-degree, logarithmic polynomial based on water temperature. *Penilia avirostris* occurred throughout the year, usually attaining higher biomass and production during warmer seasons, above the thermocline. However, some winter maxima were also observed. No correlation was observed between chlorophyll *a* concentration or temperature and *P. avirostris* biomass or production (Spearman's rank correlation, $P > 0.3$). Biomass ranged from 0.006 to 14.7 mg C m^{-3} (mean ± SD = 1.74 ± 2.84 mg C m^{-3}), and production ranged from 0.001 to 1.61 mg C m^{-3} d^{-1} (mean ± SD = 0.26 ± 0.37 mg C m^{-3} d^{-1}). Annual production based on the mean production of the three years studied was 95.1 mg C m^{-3} y^{-1}. This value corresponds to 12% of the annual production of the main holoplankton taxa (copepods + larvaceans + *P. avirostris*) off the southeastern coast of Brazil. This result confirms the importance of this marine cladoceran to the trophic structure of tropical and subtropical coastal areas.

S5-6920

Zooplankton biomass and production in the coastal upwelling zone off the Chilean Humboldt Current System

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In the coastal upwelling zone off Chile, copepods and euphausiids comprise the bulk of the zooplankton biomass (>80%). We assessed spatial and temporal variation of metazooplankton biomass and production over the upwelling zone off central/southern Chile for the period 2004-2009. Biomass was estimated directly from dry weights and carbon measurements. Production was estimated from growth rates and the corresponding biomasses for 3 size-categories of copepods: large-sized, mid-sized and small-sized, and euphausiids, represented by the dominant species, *Euphausia mucronata*. During the upwelling season (spring-summer) euphausiids were the greatest contributors to biomass, whereas under non-upwelling conditions (fall-winter) small-sized copepods dominated zooplankton biomass. Copepod mean growth rates were 0.09, 0.26 and 0.42 d^{-1} for large-, mid- and small-sized copepods respectively, and that of *E. mucronata* was estimated as ca. 0.022 d^{-1} (annual mean). We analyzed the sources of variance for biomass estimates and day-night samples, and found spatial replication to be critical, requiring the use of correction factors. We estimated that about 4 g C m^{-2} d^{-1} can be produced (in the upper 200 m) during the upwelling season, and in all cases, small-sized copepods contributed most to zooplankton production. Small copepods feed mainly on heterotrophic nano- and microplankton, suggesting a largely heterotrophic, although highly efficient, pathway for phytoplankton carbon in the Humboldt Current. Mean annual biomass and production varied strongly from year to year during the study period, which was dominated by strong upwelling under the prevailing La Niña conditions. Interannual variation in upwelling partly explains annual zooplankton production, suggesting bottom-up control of zooplankton is important in this system.

S5-6969

Oithona nana: population dynamics at the EPEA coastal station (38º28´S 57º41´W) and at the Rio de la Plata estuarine front

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The key role of *Oithona* spp. in coastal marine ecosystems is being increasingly recognised worldwide. In Argentine coastal waters, *Oithona nana* is one of the dominant copepod species. Nevertheless, studies on the ecology of this species are still incipient. We investigated the annual population dynamics (copepodites CI-CV and adults) and seasonal variations in prosome length (PL) and reproductive parameters of this species at the EPEA (Estación Permanente de Estudios Ambientales) coastal station (38º28´S 57º41´W). The same ecological parameters were studied in two sections of the Rio de la Plata estuarine front (RdPF) during spring. *O. nana* occurred throughout the year at the EPEA station, varying between 36 ind. m^{-3} (0.07 mg C m^{-3}) in May and 5,800 ind. m^{-3} (7.58 mg C m^{-3}) in January. PL of each stage was shortest in summer-autumn compared to spring-winter. Clutch size was constant, but egg diameter varied seasonally. At RdPF, *O. nana* abundances increased seawards from 761 ind. m^{-3} (0.98 mg C m^{-3}) at the inner brackish water stations to ~7,000 ind. m^{-3} (9 mg C m^{-3}) at the mid-estuarine stations. At the offshore marine stations, *O. nana* was replaced by *O. helgolandica* (*sensu* Ramirez, 1969). PL of each stage varied spatially without a discernible pattern. No variation was detected in clutch size or in mean egg size at RdPF. During spring, *O. nana* was two (females, CIV, CV) or even three (CI-CIII) times higher at RdPF than at EPEA, whereas abundance of males was similar. The results will be discussed in relation to the environmental variables, and the influence of the RdPF influence will be highlighted.

S5-6972

Monitoring ciliate populations in Thau lagoon (South of France)

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Spatial and temporal monitoring of ciliate populations (naked ciliates and tintinnids) was conducted in Thau lagoon, on the French Mediterranean coast. Three contrasting stations (Station 1: affected by strong sea water inflow, Station 2: close to some oyster farms, Station 3: in a harbour) were sampled twice a month during one year. Species were identified and enumerated using Üthermol sedimentation chambers.

Ciliate concentrations ranged between 21 and 4,977 cells L^{-1}. Strong variations in species abundance and diversity were observed between stations as well as seasonally. For example, while 15 species were observed at Station 1 on the 20th May 2010, only 6 were identified at Station 3. Relationships between environmental parameters (temperature, dissolved oxygen, nutrients, pH, chlorophyll *a*) and population dynamic of naked ciliates (*Strombidium* sp., *Strobilidium spiralis*, *Strombidinopsis* sp., *etc.*) and tintinnids (*Tintinnopsis corniger*, *Helicostomella subulata*, *Eutintinnus* sp, etc.) are discussed.

Predator-prey relationships between ciliates and phytoplankton were observed with a new approach using a Confocal Laser Scanning Microscope. Samples were optically z-sectioned into 0.9-µm diameter layers, and wavelength excitation was determined with a laser, in order to observe chlorophyll *a* fluorescence of phytoplankton cells. The advantage of this method, compared to using an inverted microscope, is the ability to confirm the ingestion of prey by ciliates, and to potentially identify the types of predators and prey ingested.

S5-6977

Size fractions of mesozooplankton (Copepoda and Appendicularia) in relation to first feeding larvae of anchovy (*Engraulis anchoita*) during spring of 2004 at the frontal system of Peninsula Valdes (42-44ºS), Argentina

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A frontal tidal system occurs at the north Patagonian coastal area during spring-summer which maintains several commercial fishes such as anchovy (*Engraulis anchoita*). We investigated the spatial distribution in abundance of different size fractions of copepods and appendicularians in relation to the distribution of first feeding larvae in the different sectors of this front. Twelve samples of zooplankton and ichthyoplankton were collected with Mini-Bongo (67µm) and Pairovet (200µm) nets along two transects crossing the front; CTD profiles were also recorded. Stratified and homogeneous waters were distinguished taking into account the distribution of the Simpson stability Index. Total abundance was higher in homogeneous waters, mainly at the southern transect. Mesozooplankton was divided into three size categories. As a whole, we observed that the dominance of the smallest fraction of mesozooplankton (<500µm) at coastal stations coincided with the highest larval abundance (max. 6,000ind. $10m^{-2}$), while the dominance of the largest fractions (500-1,000µm and >1,000µm) at outside stations coincided with the highest egg abundance (max. 50,000 eggs $10m^{-2}$). The largest calanoids (2,100µm), cyclopoids (1,700µm) and nauplii (600µm) were found at the outside stations but the largest appendicularians (1,500µm) were found at the coastal stations. The physical structure of this front seems to enhance food availability for first feeding larvae, with calanoid and cyclopoid copepods the main food items, followed by nauplii and appendicularians. The abundance of such mesozooplankton food is likely to be important for the survival and growth of fish larvae in this frontal system.

Poster - S5

S5-6998

Spring zoo- and ichthyoplankton of the Pacific Ocean waters adjacent to Kamchatka in 2006-2007

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Samples were collected during zoo- and ichthyoplankton surveys in the Pacific Ocean waters adjacent to southeastern Kamchatka (Russia) in April-May 2006-2007. Zooplankters were sampled in the upper layer (50-0 m) with a Juday net (BSD). Fish eggs and larvae were sampled with an egg cone net (IKS-80) hauled vertically to the surface, with a maximum sampling depth of 630 m. The number of samples collected in 2006 and 2007 was 61 and 70 respectively.

Zooplankton included 35 species and morphs of plankters from 16 taxa. The main species comprising the zooplankton biomass were *Neocalanus plumchrus*, *N. cristatus*, *Eucalanus bungii*, *Metridia pacifica*, *Oithona similis* and *Pseudocalanus minutus*.

Ichthyoplankton consisted of developing eggs, larvae and fry of 22 fish species from 11 families. Eggs of walleye pollock *Theragra chalcogramma* and larvae of rougheye rockfish *Sebastes aleutianus,* shortraker rockfish *S. borealis,* tadpole snailfish *Nectoliparis pelagicus*, sculpins *Myoxocephalus sp.* and *Gymnacanthus sp.*, northern smoothtongue *Leuroglossus schmidti* and Pacific sand lance *Ammodytes hexapterus* were most abundant.

Greatest concentrations of zooplankters, eggs and larval fish were observed in the southern part of the Avachinsky Gulf and in the vicinity of southeastern Kamchatka. The high concentration of forage planktonic organisms and their consumers (larvae and fry) in these areas is likely to be favorable for fish survival during early ontogenesis.

S5-7031

Zooplankton structure and succession at the EPEA coastal station (northern Argentina): Dominance of the smaller size fractions

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The community structure and seasonal succession of zooplankton was studied at the EPEA (Estación Permanente de Estudios Ambientales) coastal station (38°28´S 57°41´W) during an annual cycle (March 2000-April 2001). Monthly samples were obtained with a small bongo net (mesh size 67 µm). Small copepods (< 1mm total length), represented mostly by *Oithona nana* and members of *Paracalanus-Ctenocalanus*, dominated the mesozooplankton throughout the study year, outnumbering larger copepods by two orders of magnitude. In summer, small copepods were also dominant in terms of biomass. Highest densities of large copepods (>1 mm total length) *Calanoides carinatus* and *Ctenocalanus vanus* were observed mostly in winter and early spring. *Oikopleura dioica* and *Penilia avirostris* were the dominant appendicularian and cladoceran species respectively. They exhibited increased densities in summer. *Noctiluca scintillans* was strongly dominant during spring and early summer whereas *Sagitta friderici* showed increased densities in fall and summer. Lamellibranch larvae peaked during winter and early spring, coinciding with the reproductive cycle of the adults. Zooplankton community succession exhibited two clearly different periods throughout the year: 1) a cold winter-spring period characterized by a classical, largely herbivorous food web, in which large copepods *C. carinatus, C. vanus* and lamellibranch larvae were associated with lowest temperatures and highest densities of Chl-*a* and microphytoplankton, and 2) a warm spring-summer period dominated by small copepods and microbial filter-feeders like *O. dioica* and *P. avirostris*, and characterized by highest density of picoplankton and lowest concentration of Chl-*a*. The potential implications of the zooplankton seasonal succession for higher trophic levels are discussed.

S5-7058

Does untreated sewage discharge affect the zooplankton community? A case study in a turbid estuary (Bahía Blanca, Argentina)

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The Bahía Blanca Estuary receives untreated sewage from a growing urban population. To investigate whether the contribution of allochthonous organic matter affects the mesozooplankton community, surface tows were made in the channel which receives the sewage input (Canal Vieja, CV) and in a control site (Bahía del Medio, BM). Sampling was conducted during summer and winter of 2009. As expected, the disturbed site (CV) presented significantly higher values of nutrients (except silicates), ammonium and temperature and lower values of pH, dissolved oxygen and salinity. Phaeopigments were consistently higher at BM. Although both sites presented similar zooplankton species composition, dominance was different. The native copepod *Acartia tonsa* dominated during summer at BM, showing its maximum abundance there (9,610 ind. m^{-3}) coinciding with historical data. At CV, *A. tonsa* codominated with the crab *Neohelice granulata* zoeae, the latter with a maximum abundance of 1,383 ind. m^{-3}. Observations of the microheterotrophic community yielded information on typical assemblages, and indicated higher abundances at BM. Extremely high abundance of aloricate ciliates, especially *Lohmmanniella* sp., was observed at CV. High turbidity, coupled with the contributions of the vast expanse of surrounding salt marshes, contribute to the elevated basal eutrophication level of this well mixed system. Zooplankton in this region are thus likely to be adapted to high organic matter content. Nevertheless, some differences in planktonic variables between the sites were observed. These may be the first biological signs of an allochthonous eutrophication process. However, the geomorphology and circulation patterns of this estuary are likely to minimize the effect of the untreated sewage discharge.

S5-7059

Seasonal distribution and biomass of copepods in the Thoothukudi coastal waters of the Gulf of Mannar, southeast coast of India

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Thoothukudi coastal waters are part of the Gulf of Mannar, which is uniquely influenced by both southwest and northeast monsoons, and is known to be one of the richest biodiversity spots of India. As a result of the high biodiversity, this part of the Gulf of Mannar has been declared as the first Marine Biosphere Reserve in Southeast Asia, and also as a Marine National Park. This region is reknowned for its diverse fishery resources such as pearl oyster (*Pinctada fucata*), sacred chank *Xancus* (=*Turbinella*) *pyrum*, coral reefs, a variety of seaweed species, seagrasses, cephalochordates (*Amphioxus* sp.), hemichordates (*Balanoglossus* sp., *Ptychodera flava*) and marine mammals, in particular sea cow (*Dugong dugon*). Presently this coast is highly influenced by various pollutants due to urbanization and industrialization in general, and by the discharge of untreated domestic sewage in particular. With this in mind, the present investigation was carried out to investigate the influence of sewage on the seasonal distribution, biomass and density of copepods with reference to environmental factors in the Thoothukudi coastal waters. This study was conducted during November 2004 – June 2005 at two stations: Station 1, which is a coastal site receiving sewage, and Station 2, which is far from the coastal site and is not influenced by sewage. Copepod density ranged from 32,000 to 89,000 ind. m^{-3} at Station 1, and from 64,000 to 135,000ind. m^{-3} at Station 2. The dominant copepod species at Station 1 were *Oithona brevicornis, O. linearis, O. rigida, Euterpina acutifrons* and *Longipedia coronata*, whereas at Station 2 the dominant species were *O. brevicornis, O. linearis, Acartia erythraea, Eucalanus* sp., *Corycaeus danae* , *Euterpina acutifrons*, *L. coronata* and *Microsetella norvegica*. The total number of copepod species recorded during the study periods were 12 and 25 at Stations 1 and 2 respectively. The number of copepod species recorded at any one time of the study ranged from 6 to 10 at Station 1, and from 6 to 17 at Station 2. The maximum number of copepod species occurred during November 2004 and April 2005, while the minima were during June 2005 and May 2005 at Stations 1 and 2 respectively. The total biomass of zooplankton and the interrelationship between copepods and other zooplankton, as well as the influence of other water quality parameters on the distribution of zooplankton, are discussed in detail.

S5-7083

Zooplankton community response to disturbance following a flood event in a subtropical bay, Australia

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Freshwater input in low latitude estuaries is punctuated by ephemeral, high-energy flood events during the wet season that transport substantial nutrient loads and suspended solids from the catchment to receiving waters. Plankton communities can respond to nutrients delivered in flood events, and increases in phytoplankton biomass and primary productivity have been reported following run-off events. Less known, however, is how zooplankton communities respond to, and recover from, such disturbances, and the transfer of nutrients from primary producers to higher trophic levels. The focus of this study is to examine impacts of nutrient inputs and physico-chemical disturbances on zooplankton dynamics following a flood event, and to determine the most important trophic pathways within the plankton community in subtropical Moreton Bay (Australia). A flood event in February 2010 provided an opportunity to collect and analyse zooplankton samples for abundances, biomass, species composition and size spectra alongside a range of environmental variables including nutrient and chlorophyll *a* concentrations, salinity, temperature, and turbidity. Generalised linear models and multivariate analyses were used to determine the most significant drivers affecting zooplankton communities. We found sharp declines in zooplankton abundances due to flushing from the system and/or mortality from environmental extremes, followed by increases in microzooplankton. Shorter generation times of the microzooplankton allow a more rapid response to increased food supply, while larger, slower-growing mesozooplankton are less tightly coupled to phytoplankton biomass. The return to non-flood conditions for the various plankton components was slower for the larger size fraction of zooplankton. This information is being used to develop indicators of eutrophication and to calibrate a receiving water quality model for the region.

S5-7094

Estimation of secondary production in Patos Lagoon Estuary (Brazil): Methodological aspects

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Despite the huge importance of secondary production in the water column, there is no consensus on the most reliable method to estimate this parameter. During the last decades, egg production and cohort analyses have mainly been used. However, these techniques are not well resolved in space and time, and they are difficulty to apply to an entire community. As crustaceans, mostly copepods, dominate oceanic and estuarine zooplankton, methods based on growth rates of these organisms are frequently developed. The goal of this study was to estimate zooplankton production in the Patos Lagoon estuary (Southern Brazil, RS) using both chitobiase and mathematical models. Methods were applied to data collected during seasonal sampling at five sites in the estuary. By applying the equations in Huntley & Lopez (1992) and Hirst & Bunker (2003), highest production occurred in winter, corresponding to 4.4 and 3.8 mg C m^{-3} d^{-1}, respectively. The lower values were registered in the fall, corresponding to 0.3 and 0.05 mg C m^{-3} d^{-1}, respectively. Production estimated using the chitobiase method showed higher values than those obtained with the mathematical models, corresponding to 5.4 mg C m^{-3} d^{-1} in winter and 1.2 mg C m^{-3} d^{-1} in the fall. However, the same seasonal pattern was observed. These results show that the chitobiase method may also be useful for estimating zooplankton production in estuaries, as has previously been shown for marine environments by Sastri & Dower (2009).

S5-7098

Comparative studies on zooplankton (micro- and mesozooplankton) in two oligotrophic areas of the Central Western Mediterranean

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The Balearic Sea (Central Western Mediterranean) is an ecologically important area that encompasses major spawning areas of pelagic fish, possibly due to an 'island stirring' effect that produces an increase in plankton biomass around the islands as a result of disturbance of the oceanic flow. Hence, the Balearic Sea is a key site to track the dynamics of plankton and water exchange into the WM and the effects on the structure of the pelagic ecosystem. In this paper, and within the framework of the IDEA2 project, we investigated the biomass and composition of the zooplankton communities (micro- and mesozooplankton) and their relationship with the environment in the northern and southern waters off the Balearic Islands.

Comparative studies conducted at two different depths (200 and 900 m) during winter (2009) and summer (2010) showed that the communities differed in terms of species richness and productivity. In both the well-mixed (winter) and stratified (summer) seasons, copepods and their nauplii were the most abundant group, followed by appendicularians and other thaliaceans. During the well-mixed season, biomass was higher in the northern region, and was dominated by the largest size fraction (>500um). Microzooplankton however, was more abundant during the stratified season. Major zooplankton groups and dominant species were used to define the pelagic communities. Other minor groups, such as siphonophores, chaetognaths and doliolids, were important indicators of productivity in the ecosystem.

S5-7108

Temporal and spatial variation of hyperiid amphipod assemblages in the eastern tropical pacific off Colombia (2007-2008)

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We evaluated the temporal and spatial variation of the structure of hyperiid amphipod assemblages in the Colombian Pacific in relation to the local hydrographic dynamics. Four oceanographic cruises were carried out during 2007-2008 (dry season: Feb 2007 and Mar 2008; rainy season: Sep 2007 and Sep 2008), where temperature and salinity were measured and zooplankton samples were collected (200m to surface). Colder (<20°C) and saltier waters (34) were registered during the dry season, while the opposite pattern was observed during the rainy season (temperature >25°C, salinity <33). Seventy hyperiid species were found; *Hyperioides sibaginis* and *Lestrigonus bengalensis* were the most frequent (>70%) and abundant (76%). Higher diversity, abundance and biomass were in general observed during the dry season and in the oceanic region. As a consequence of the hydrographic variability associated with the coastal-oceanic gradient, we found that the structure of the hyperiid assemblages changed spatially. In the rainy season, two assemblages were established: one in the coastal area, characterized by low diversity and a high dominance of *H. sibaginis*, and another for the oceanic region, with high diversity values, and with *H. sibaginis, L. bengalensis*, *Lestrigonus schizogeneios* and *Hyperietta vosseleri* contributing mainly to the similarity. In contrast, the structure was spatially similar during the dry season, with *H. sibaginis, L. bengalensis, L. schizogeneios, Hyperietta parviceps* and *Phronimopsis spinifera* contributing mainly to the similarity. Finally, the abundance of hyperiids was significantly correlated with the abundance of potential gelatinous zooplankton hosts (siphonophores, ctenophores, doliolids and salps).

S5-7139

Mesozooplankton community structure in Bahía de La Paz, Mexico

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The abundance and community structure of mesozooplancton (333µm) were studied in October and December 2003, February, June and August 2004 at a fixed station in order to analyze the changes of mesozooplankton community and copepods, as well as its relationship with the surface of the sea and the concentration of chlorophyll *a* and sea surface temperature. The mesozooplancton was separated into functional groups, standardizing the abundance to 1 m³ filtered water. In 50 zooplankton samples, a total of 20 systematic groups were identified. Maximum abundance was found in June (>1500 org·m^{-3}) and minimum in February (260 org·m^{-3}); copepods, cladocerans and decapods were the most abundant and frequently-occurring taxa. Thrity-two species of copepods were identified; their abundance varied between 300 and 600 indiv·m^{-3}, species richness varied between 21 and 23. *Centropages furcatus Canthocalanus pauper* and *Acartia lilljeborgii* were the most frequent and abundant copepods. The highest diversity was estimated in February (3 bits·ind^{-1}) and lowest in June (2 bits·ind^{-1}), indicating a relatively stable community. Biogeographical affinity was predominantly tropical (≈80%); 25-40% of the species were herbivorous. The relationship between the copepod abundances and sea surface temperature was not significant. The proportion of herbivore copepods varied between 27 and 41% and was significantly correlated with the variation in chlorophyll *a*. The abundance of the copepods showed a maximum in the summer, seemingly due to high concentrations of chlorophyll *a*.

S5-7147

Seasonal and inter-annual variability in copepod species composition and egg production related to climate and upwelling dynamics in the northern California Current

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The copepods *Calanus marshallae* and *C. pacificus* are major components of the zooplankton assemblage in the northern California Current (NCC) seasonal upwelling system. These two species are often associated with different water masses, with *C. marshallae* primarily a boreal, neritic species and *C. pacificus* a sub-tropical, offshore species. Hence, their presence along the Oregon shelf is indicative of the advection of different water masses onto the shelf. Using a 15 year (1996 – 2010) dataset of bi-weekly measurements of cross-shelf hydrography, species life-history stage abundance, and egg production rate, we examine the variability in these parameters in relation to upwelling dynamics (local forcing) and shifts in climate as indexed by the Pacific Decadal Oscillation (PDO) and Multivariate ENSO Index (MEI). Generally, positive phases of the PDO and MEI are coincident with higher abundances and proportions of *C. pacificus* over the shelf, whereas negative phases favor *C. marshallae*. The timing of first appearance of an assemblage of boreal, neritic copepods that includes *C. marshallae* indicates a 'biological transition' from winter to summer, and can lag the physical upwelling transition anywhere from days to months. Egg production rates average 26.7 eggs per female, but vary considerably both inter-annually and seasonally. Here, we investigate how basin-scale and local-scale forcing influence secondary production in an upwelling system.

S5-7155

Climate, hydrography and invasive species driven decadal variability in zooplankton of the highly stratified Sea of Marmara

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The major fraction of Sea of Marmara zooplankton is confined to a thin upper layer as a result of the strict thermohaline stratification. The upper layer, receiving anthropogenic influxes from the Black Sea and through local surface discharges, constitutes a highly productive system and on contrary to its physical structure, Marmara upper layer zooplankton is significantly different than the neighboring basins. One of the most distinguishing characteristics is that it is a Cladocera dominanted system. Monthly zooplankton observations from March 1999 to December 2008 revealed that Cladocera dominance in mesozooplankton that reached 64% in 1999–2001 has declined to 41.7% in 2004–2006. In addition, abundance of major zooplankton species, such as *Acartia clausi*, *Penilia avirostris* and *Sagitta setosa* has decreased, while *Paracalanus parvus* increased. Time series analysis identified fluctuations in the North Atlantic Oscillation Index as an important controller of total zooplankton abundance and community structure, in addition to temperature and chlorophyll *a*. High correlation among zooplankton and *Noctiluca scintillans* (as the major competitor of mesozooplankton) abundance trends (r=0.90) indicated that observed variability has affected different levels of secondary production in the basin. Moreover, the introduction of *Liriope tetraphylla* in autumn of 2005, and its high abundance in 2006 and 2007 (>3000 ind.m^{-3}) has caused significant shifts in zooplankton abundance and community structure, through structuring non-temperature dependent patterns in zooplankton community. The massive mucilage phenomenon witnessed in 2007–2008 suggests that Marmara ecosystem is facing a major change; increasing water temperatures and variations in zooplankton comprise an important step of this change.

S5-7164

Nitrogen excretion by mesozooplankton in a coastal upwelling area: Seasonal comparison and implications for biological production

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Nitrogen excretion by zooplankton was studied using numerically dominant copepods of the mesozooplankton community during two contrasting periods (winter and spring) of 2009 in the coastal upwelling area off Concepción (36°S) in central/southern Chile. The experimental setup aimed to characterize the organic and inorganic nitrogen excretion compounds, such as dissolved organic nitrogen (DON), urea, and ammonium. It also focused on relating these excretion products to seasonal variations such as the amount of microphytoplankton and nanophytoplankton, and nutrients concentration (NH_4^+, NO_3^-, NO_2^-, PO_4^{-3}, $Si(OH)_4$). We tested the hypothesis that ammonium supplied by mesozooplankton (represented by copepods) can support a significant fraction of the nitrogen demand of phytoplankton. To do so, excretion rates were determined and the budget of each nitrogen compound was assessed. Results showed that among the organic and inorganic nitrogen compounds, total DON (*i.e.*, ureic and non-ureic components) may be the most important excretion component for copepods, which contrasts with findings of previous studies which suggested that ammonium is the main nitrogen compound excreted by mesozooplankton. Overall, the total (organic and inorganic) nitrogen excretion per group of dominant copepods in the continental shelf could have a significant impact on the nitrogen requirements by the phytoplankton communities, potentially sustaining up to 26.7% of the phytoplankton ammonium demand.

S5-7195

Zooplankton in a groundwater formatted pockmark field (Eastern Mediterranean)

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Pockmarks are depressions in soft ocean substrates, observed on continental shelves or deeper oceanic beds and involved with seabed fluid flow (gas, groundwater, seawater). Observations of higher benthic activity and diversity, along with implications of a complex hydrodynamic and chemical profile, make pockmarks a challenging study area. Unlike the bottom, the water column inside pockmarks has not been actually studied, and zooplankton data are completely lacking. Echographic studies in the Gulf of Corinth (west Greece, Eastern Mediterranean) have revealed a field of 20 groundwater flow-induced pockmarks with maximum opening of 60m and a maximum depth of 15 m. Among them, a narrow and deep pockmark was studied for its biotic and abiotic components in the water column during spring and autumn. Replicates of water samples for Chl-*a* and nutrients estimations were taken from inside and outside the pockmark, on a surface transect passing over its center. Microzooplankton and mesozooplankton samples were collected using two closing nets (45 and 200µm), while salinity and oxygen profiles were recorded using a CTD. Hydrology, as well as biological data observed, revealed upwelling within the pockmark. The results of the zooplankton community analysis are discussed.

S5-7247

Ontogenetic and seasonal changes in diel vertical migration amplitude of the calanoid copepods *Eurytemora affinis* and *Acartia* spp. in a coastal area of the northern Baltic Proper

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We studied diel vertical migration (DVM) of the six copodite stages of the calanoid copepods *Eurytemora affinis* and *Acartia* spp from May through October, in a bay in the northwestern Baltic proper. Fish biomass, temperature and light intensity were measured in conjunction with the zooplankton sampling. Both species performed DVM. *Acartia* spp DVM amplitude increased with stage and size suggesting an ontogenetic shift in behaviour but had a less pronounced DVM than *Eurytemora affinis*. All copodite stages of *Eurytemora affinis* performed migrations of over 10 meters with only a slight increase with body size. However adult specimens of female *Eurytemora affinis* remained at depth with only slight upward movement at night. Though DVM amplitude increased with size indicatory of visual predation, fish biomass did not have a significant impact on the amplitude of DVM. However, fish were present throughout the year. We surmise that these ontogenetic shifts in behaviour are due to size increase and therefore visability to predators and that the difference in DVM between the species may well be a result of physiological differences and reproductive strategy.

S5-7249

Tidal effects on the zooplankton composition and abundance in a coral reef lagoon (Toliara, Madagascar)

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Zooplankton distribution was investigated in two seasons at a network of 10 stations sampled during neap tide and spring tide conditions. Abundance and biomass of metazooplankton were significantly higher during spring tide (ST) than neap tide (NT) conditions and this pattern was invariant over the two seasons (ANOVA, $p<0.05$). This variation was accompanied by change in taxonomic composition and size-structure, with a significant reduction of the mean size between ST and NT. This result was interpreted as resulting from an "importation-retention" phenomenon, *i.e.* passive importation of zooplankton in the lagoon during the flood, selective export during the ebb, a part of the community (especially the large calanoids) being resistant to export because of migratory behavior (tidally orientated diel vertical migration). This phenomenon, which is more accentuated during spring tide, could be a key mechanism for lagoon zooplankton enrichment and renewal.

S5-7263

Spatial structure and diel changes of the zooplankton community along the Garrucha canyon (SW-Spain) as derived from dissecting microscope, ZooImage, and FlowCAM analysis

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The Alborán Sea is the transition region between the Atlantic Ocean and the Mediterranean Sea. Its main circulation pattern is well known as its hydrological eastern boundary is the Almeria-Oran front. It has been the subject of several macroscale oceanographic studies. However, little is known about the mesoscale circulation pattern and the associated distribution of zooplankton, particularly where the Almeria-Oran front approaches the coast, around Cape of Gata. This area is comprised of prominent canyons and seamounts that interact with the front, coastal currents, and eddies, which generate turbulence that might fertilise the water column. In the framework of the CETI (Spanish national project: CTM2008-05695-C02-02), a multidisciplinary mesoscale sampling program with special emphasis on the zooplankton is being carried out around the Cape of Gata.

Four LHPR net hauls (12 layers between 0-400 depth metres) were taken along the main submarine canyon (La Garrucha) with the aim of analyzing the spatial structure and nictemeral changes of the zooplankton community. Additionally, a selected set of samples from the deep chlorophyll maximum are being analyzed using a set of methods including optical microscopy and novel image analysis systems (ZooImage and FlowCAM) for comparison. Preliminary results show qualitative and quantitative differences between the zooplankton community at daytime and nightime as well as at the head (close to the coast) and the mouth (2000m) of the canyon. The results are discussed in the context of the main circulation patterns found at mesoscale.

S5-7272

How copepod growth may respond to distinct upwelling regimes?

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The Humboldt Current Ecosystem (HCS) exhibits variable upwelling regimes over the latitudinal gradient from 5°S to 42°S. Individual species of copepods species may distribute across these gradients from tropical-subtropical to temperate-Austral regions. In northern Chile, upwelling is intermittent throughout the year whereas in Central/southern Chile, upwelling is strongly seasonal and mostly concentrated in the Austral spring-summer. It is unknown how copepod populations respond to these variable regimes, although previous studies suggest a strong dependency of development and growth rates on upwelling variation. The present work examined the variability of copepod growth rates (g) over different upwelling regimes (seasonal and intra-seasonal variation), as estimated by the molting rate method. At northern Chile (~23°S), *Paracalanus indicus, Acartia tonsa* and *Calanus chilensis* showed weight-specific g between 0.1 and 0.3 d^{-1}, with averages of 0.20, 0.16 and 0.17 d^{-1} respectively. At Central/southern Chile (~36°S), *P. indicus* yielded a g between 0.1 and 0.5 d^{-1}, with an average of 0.35 d^{-1}. The apparent lack of significant differences in g between regions suggests the presence of physiological adjustment to cope with a highly heterogeneous upwelling environment, allowing high and sustained growth rates despite variation in temperature and food resources. Sustained growth rates can also support high copepod abundances and a greater efficiency to convert phytoplankton C into zooplankton biomass upon variable upwelling intensity.

S5-7273

Temporal variability of copepod community in the Bahía de La Paz, México

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Abundance and diversity of copepod community structure were studied at a fixed station in the Bahía de La Paz between October 2002 and February 2004; during ten days in seven sampling campaigns the copepod community was sampled in order to analyze their variation in relation to sea surface temperature and chlorophyll *a* concentration. Adult copepods were identified and numbered standardizing to 100 m^3 filtered water. From 66 zooplankton samples 71 copepod species were identified. Rank abundance varied between 38,341 and 263,550 indiv·100 m^{-3}.

The most frequent and abundant species were *Centropages furcatus, Subeucalanus mucronatus* and *Undinula vulgaris*. Species richness was highest in January 2003 (10–31), and highest species diversity in October 2002 (0.6–1.1 *bits*/ind). Species richness showed a negative trend from June 2003 on, in contrast to diversity, indicating an evenness of species abundance and a relatively stable community. The community structure and species richness were negatively correlated to chlorophyll *a* concentration; diversity of copepods increased slightly with increased sea surface temperature. From June 2003 on, copepod abundance declined, and showed no apparent relationship with se temperature or chlorophyll *a* concentration. Future analyses need to involve additional variables as well as vital rates of dominant species in order to explain our findings.

S5-7282

Seawater temperature, α-chlorophyll and zooplankton samples support a new paradigm: Coastal waters off northern Patagonia play a major role as spawning and nursery areas for early life-cycle planktonic stages of the Argentine squid *Illex argentinus*

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Illex argentinus sustained the world's largest cephalopod fisheries during the last decade. Based on the spatial distribution of mature individuals and paralarvae on the confluence of Brazil-Malvinas currents and the mid/outer shelf off northern Patagonia, researchers have interpreted that major spawning stocks having distinct life-cycle chronologies segregate during discrete time periods in specific areas of the mid/outer shelf and shelf break off Argentina to Southern Brazil, and that either: 1) neutrally-buoyant egg-masses drift to the confluence of Brazil-Malvinas currents (B/M-C) where hatching might take place, or 2) mature females migrate long distances to the B/M-C to spawn. However, alternative life-cycle hypotheses involving the use of coastal areas as spawning and nursery grounds have not been explored. In this study we evaluate the suitability of different areas of the species' range for early life-cycle development by spatially modeling a combined function of the monthly probability of: 1) embryonic survival, based on experimental data and SST remote sensed information (NOAA-AVHRR), and 2) paralarvae survival, based on primary productivity availability estimates (chlorophyll *a* concentration, SeaWiFS). Also, we sampled coastal waters off northern Patagonia searching for paralarvae of *I. argentinus*. Our model shows that coastal areas may play a major role as spawning and nursery grounds of the species that has been previously neglected. Also, we confirmed our predictions by reporting the finding of paralarvae of *I. argentinus* in zooplankton tows conducted in coastal waters off Patagonia and of juveniles (25-39 mm ML) found stranded on the coast at 42.8ºS.

S5-7295

Planktonic amphipods distribution in upwelling zones in northern Humboldt Current System

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In order to better understand planktonic amphipods composition, distribution and diel distribution in the upwelling zone of the Northern Humboldt Current System (NHCS), we analyzed zooplankton samples and hydrographic conditions collected during the *Filamentos* cruise in February 2008. On board the *R/V Jose Olaya Balandra*, twenty multi-disciplinary stations were sampled along cross-shore sections (3 nm to 120 nm from the coast) located in an upwelling region of the NHCS (6.5°S–8°S). At these stations, zooplankton samples were collected in 9 stratum of the water column (500-0 m) using a Multinet.

Twenty nine species were found. The most abundant amphipods collected were *Ampelisca* sp. (35.5%), *Themistella fusca* (35.6%) and *Vibilia armata* (19%). These species showed a wide migration: *Ampelisca* sp. in daytime resided between 75–300m of the water column; at night it was found in the upper column above 75 m. Meanwhile *T. fusca* was found in upper water column (0-50m) in the daytime; *V. armata* migrated between the surface and 500m. Most others species showed a preference for the upper layer in both daytime and nighttime.

We will discuss the presence of gammaridae amphipods at the most offshore stations (100nm to 120nm offshore). This research provides new information regarding a scarcely studied component of the zooplankton in upwelling zones in northern Humboldt Current System and increases the number of hyperiid species reported for the Pacific Ocean off Peru.

Poster - S5

S5-7303

Key copepods in a coastal upwelling area in the Northern Humboldt Current System

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here is little information on the composition, abundance, and dynamics of copepods in the coastal upwelling area of the Northern Humboldt Current System where fishing effort on anchovy and other species is high. From 1997-2009, copepods were collected from the upwelling zone and Callao, between 2 and 20 nm from the coast with a WP2 net towed at the surface. The results reported that *Acartia tonsa*, *Paracalanus parvus* and *Centropages brachiatus* were the most important species. However, *A. tonsa* had the highest abundances with 30,000 individuals.m^3, whereas *P. parvus* had intermediate abundances with 21,253 individuals.m^3 and *C. brachiatus* showed the lowest abundances with 3,110 individuals.m^3 *A. tonsa* was present (99%) in all periods, whereas P. *parvus* and *C. brachiatus* were variable, occurring in ~73% of samples. *C. brachiatus* showed a substantial decline when oceanographic conditions indicated warm conditions. Thus, the mean abundances were lowest (12 individuals.m^3) in the 1997-98 El Niño. There is an inverse relationship between the abundance of *A. tonsa* and *P. parvus*, which related to oceanographic conditions. We will discuss the importance of these species as keystone species in upwelling areas.

S5-7304

Zooplankton size spectra obtained by LOPC from Abrolhos Bank

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Abrolhos Bank is at the Eastern coast of Brazil and harbors an important ecosystem that encompasses a large marine biodiversity, with rich and productive waters that exert influence on the economic and social dynamics of the area. Receiving influence from the Brazil Current (BC) the area is characterized by a mixture of oligotrophic Tropical Water (TW) and nutrient rich South Atlantic Central Water (SACW), which upwells in the southern region of Abrolhos near the continental slope. In order to identify the zooplankton occurring in that region during summer (January, 2009), 19 samples were obtained using an 80 µm plankton net towed together with a Laser Optical Plankton Counter (LOPC) and a CTD to simultaneously obtain environmental data. The sampling sites were chosen according to the plankton patches observed with the LOPC in water depths of 40 to 274 m over the slope. The LOPC provided data on zooplankton mean size, abundance, and biomass, as well as information on distribution and size structure, by semi-automatically quantifying community composition associated with *in situ* environmental data. Substantial variation in zooplankton distribution and abundance was observed in relation to thermocline depth and distance from the coast. The LOPC proved to be a useful and practical tool to acquire information on zooplankton with high spatial resolution providing results in near-real time and solving questions in the context of zooplankton patchiness.

S5-7306

Production of copepods upon a nearly-continuous coastal upwelling regime in the northern Humboldt Current system off Chile

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Estimates of C flux linking primary producers and zooplankton can be approached by measuring secondary production of the dominant species. In the Humboldt Current System (HCS) calanoid copepods, which dominate the zooplankton, are subjected to a semi-permanent upwelling regime, and probably do not experience food-limitation. However, they have been scarcely studied. In this study, we estimated the production of the most abundant copepods species using empirically-derived growth rates (*g*) and abundances from monthly samples in Mejillones Bay (23°S) during 2010. *Paracalanus* cf. *indicus*, *Acartia tonsa* and *Calanus chilensis* accounted for ~70% of copepod relative abundance. Monthly production exhibited a weak seasonality, with low biomass in the winter, but little variation in *g* over the seasons; the seasonality of production may have been related to increased mixing and more dispersed populations in the winter. Integrated production over an annual cycle was 7.38 g C m^2 y^{-1}, 3.24 g C m^2 y^{-1} and 1.64 g C m^2 y^{-1} for *P. cf. indicus*, *A. tonsa* and *C. chilensis,* respectively, in the upper 50 meters. Hydrographic observations showed active upwelling conditions with strong thermal stratification throughout the year and a temperature range between 17.4 and 13.8°C from surface to 90 m depth, with a weak seasonality. Our findings suggest that the small-sized copepod, *P.* cf. *indicus* has a high growth rate (ca. 0.22 d^{-1}), and may greatly contribute to copepod production in this upwelling zone, mainly because of the high and continuous turnover rate of its population which is likely growing under non-limiting food conditions year-round.

S5-7315

Metabolic responses of *Pleuroncodes monodon* larvae to low oxygen concentration

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Pleuroncodes monodon benthic populations from the Eastern South Pacific continental shelf release larve into hypoxic Equatorial Sub-Surface Waters. Larvae distribute above and within low oxygen waters where flows are contrasting; vertical migrations between them enhace chances of recrutiment. Constant low oxygen conditions decrease growth and survival of early stages. Here we analyze the short and long term responses of *P. monodon* larval metabolism to hypoxia.

Routine (RRR) and post-prandial (PRR) aerobic respiration rates were lower in hypoxia (≤1.3 $mgO_2 \cdot l^{-1}$) than normoxia in all zoeal stages. The percentage reduction in PRR was larger in early stages (87% zoea I, 47% megalopa). Zoea VIII oxyconformed with oxygen reduction, while megalopa oxyregulated. In zoea I, the rate of nitrogen accumulation was first reduced in hypoxic conditions and later arrested. C:N ratios were higher in organisms sampled from hypoxia. The aerobic potential (as Citrate Synthase specific activity, CS) and the maximum metabolic potential (as Malate Dehydrogenase specific activity, MDH), decreased in zoea I after the half moult cycle, in hypoxia. Lactate dehydrogenase specific activity (LDH) was determined as anaerobic potential. Anaerobic/aerobic potential (LDH:CS) was higher in organisms reared under hypoxia, scaling positively with age and dry weight. MDH:LDH ratios were characteristic of organisms adapted to hypoxic conditions. *P. monodon* larvae have a high capacity to tolerate low oxygen levels characteristic of subsurface waters along the South Pacific coast, nevertheless their metabolic responses together with field and modeling evidence, indicate they might endure trade-offs during development that might also apply to other species.

S6 Posters

S6-6928

Effect of rising seawater temperature on the survival of the Arctic calanoid copepod *Calanus glacialis*: A laboratory experiment

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The calanoid copepod *Calanus glacialis* (Jaschnov, 1955) has its main distribution in the relatively shallow Arctic shelf seas and often dominates the mesozooplankton biomass in the Arctic Waters of the Barents Sea. This copepod is a key species of the Arctic marine ecosystem and has been the focus of many studies focused on its spatial distribution, demography, feeding and reproduction. Little is known about its mortality. *C. glacialis* has a life cycle strategy which is highly adapted to the extremely short productive season and low predictability in timing of the onset of the spring phytoplankton bloom in the Arctic. Temperature strongly influences metabolic and physiological processes in zooplankton and the potential impact of a rise in seawater temperature could be very high especially for Arctic species. As part of the EU project Arctic Tipping Points we studied how increased seawater temperatures influence the survival of *C. glacialis*. We performed a laboratory experiment on *C. glacialis* survival at different experimental temperatures (0, 2.5, 5, 7.5 and 10°C) with focus on copepodid stages CIV, CV, and adult females. While an increase in temperature from 0°C to 2.5 and 5°C had slight to moderate negative effects on *C. glacialis* survival, higher temperatures strongly affected survival with generally higher mortality in copepodid stages CIV and CV as compared to adult females. Possible thresholds in temperature and implications on *C. glacialis* sensitivity in the cotext of climate change and rising seawater temperatures are discussed.

S6-6947

Zooplankton species composition and community structure in Western Arctic Ocean in summer 2003

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Based on zooplankton species composition and abundance from 43 stations in the Western Arctic Ocean, the community structure and geographic distribution of the dominant species and their relationships with environmental conditions were investigated. Species composition was similar to previous studies except that extremely high abundances of Ostracods were recorded in the central Chukchi Sea. The highest and average densities were 1188.9 and 186.6 ind m^{-3}, respectively. Three zooplankton communities were identified using cluster analysis: a high latitude deep ocean community (HDC) in the Canada Basin and on the Chukchi Plateau, a shelf community (SC) in the central Chukchi Sea and a neritic transition community (NTC) that included stations along the Alaska Coast and in the northern Chukchi Sea. The HDC had lowest total zooplankton abundance, and was dominated by copepods. The SC was distinguished from the NTC by the unexpected dominance of ostracods. All HDC stations were characterized by low temperature and chlorophyll-*a* concentrations. The SC included stations with high temperature and low chlorophyll-*a* concentration and also several stations with low temperature and high chlorophyll-*a* concentration. Stations from all three habitats were included in the neritic transition community. The analysis indicated that the zooplankton community in the Western Arctic Ocean was changing, more on the continental shelf than in the deep basin.

S6-7013

Effects of climate changes on the three coexisting *Calanus* species; *C. hyperboreus*, *C. glacialis* and *C. finmarchicus* during the productive season in Disko Bay, West Greenland

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This study assess how the competition between the co-existing Arctic lipid rich *Calanus hyperboreus* and *C. glacialis* and the smaller Atlantic *C. finmarchicus* may change in a future warmer climate. To investigate the importance of timing in the break-up of sea ice and spring bloom development, experiments were carried out before, during and after the spring bloom. The experiments focused on fecal pellet and egg production of the three species at temperatures ranging from 0ºC to 10ºC, combined with absence of or saturated food conditions. During each two week experiment egg and fecal pellet production was monitored daily. Prior to the bloom the production was highest for *C. glacialis* in all treatments with increasing production from 0ºC to 7.5ºC and decreasing at higher temperatures. The highest egg production of *C. finmarchicus* was observed during the spring bloom and increased over the entire temperature range. Egg production of *C. hyperboreus* was not affected by temperature and did not respond to addition of food. It is suggested that *C. finmarchicus* will be more dominant in a future warmer climate at the expense of *C. glacialis,* with huge consequences for the productivity of the area.

S6-7024

Zooplankton community across Fram Strait in autumn: Are small copepods and protozooplankton important?

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We investigated zooplankton community in September 2006/2008 at 8 stations across Fram Strait in contrasting water masses ranging from cold Polar Water (PW) to warm Atlantic Water (AW). Our main objectives were 1) to describe the plankton community in an arctic ecosystem during fall and 2) to investigate the importance of small-sized (<100µm) copepods and protozooplankton in an anticipated diapaused ecosystem, sampling both with a WP-2 net and Go-Flo bottle. We encountered a system dominated by small zooplankton and where the large Calanoids had left the surface waters. The dominant copepods at all stations were *Oithona* spp. nauplii with abundances up to $2x10^6$ individuals m^{-2}, corresponding to 440mg C m^{-2} in the upper 60m. *Oithona* spp. copepodites were the second most important group. This shift in copepod community was independent of water mass, and suggests production was sufficient to sustaine reproduction of small copepods during autumn both in PW and AW. This is further supported by small regional differences in chlorophyll *a* biomass, particulate organic carbon and phytoplankton carbon. In contrast to previous reports, small zooplankton were also important in terms of biomass and generally exceeded the biomass of the large calanoid copepods. Comparison of the sampling efficiency of the WP-2 (90 µm mesh) and the Go-Flo bottle revealed that the small copepods were significantly underestimated with the WP-2 both in terms of abundance and biomass. This emphasizes the importance of appropriate sampling for investigating carbon fluxes at lower trophic levels.

S6-7028

Plankton abundance, community structure and production across an Arctic front

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This study is part of the NESSAR project, subordinated the IPY program, and is focusing on the physical and biological processes at the fronts separating subarctic Atlantic water and cold Arctic water. During June 2007 an intensive field study of the Arctic front south of Jan Mayen in the Norwegian Sea was carried out. A transect across the front was repeatedly sampled with high spatial resolution. The transect penetrated typical Atlantic and Arctic water-masses on both sides of the front enabling us to examine zooplankton responses to environmental gradients and contrasting ecosystem characteristics of the subarctic and Arctic habitats. Hydrography, nutrients, chlorophyll *a*, phytoplankton and zooplankton (micro-, meso- and macrozooplankton) were sampled along the transect. In unison, C*alanus finmarchicus* grazing and egg production experiments were carried out. In addition to standard plankton net and trawl sampling, a towed multi-sensor platform (MESSOR) continuously collected plankton data using OPC and multifrequency acoustics. Two distinct hydrographic fronts were observed: a shallow front from the surface to 50 meter, and a deep front from 50 to 200 meter. The concentration of phytoplankton was highest in Atlantic water and decreased across the fronts and into Arctic water. Preliminary results suggest that zooplankton in Arctic water were at a less developed stage than in Atlantic water, and that *C. finmarchicus* had lower egg production rate in Arctic water. No clear differences in macrozooplankton abundance across the fronts were observed. The biological gradients across the fronts seemed less distinct than the physical gradients.

S6-7035

Zooplankton feeding in the Artic during a *Phaeocystis* bloom

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We studied the feeding rates and trophic impact of zooplankton in Arctic waters during the ATOS cruise in July 2007, in an area encompassing a latitudinal transect along the East Greenland current plus a series of stations NW of the Svalbard archipelago. The presence of *Phaeocystis pouchetii*, which formed dense blooms, was a common characteristic during the study period. Feeding rates of mixed mesozooplankton assemblages (mainly copepods) were estimated through the incubation method, both by changes in fractionated chlorophyll concentration and cell counts. Zooplankton standing stocks and vertical distribution were determined by automatic image analysis of scanned samples using ZooImage®. The estimated impact of zooplankton on primary producers as percentage of the phytoplankton standing stock daily removed was very low. It appears that the high abundance of *Phaeocystis* colonies in the area precluded the control of primary producers by mesozooplankton. Parallel experiments conducted during the cruise to determine microzooplankton grazing using dilution experiments also showed low impact.

S6-7044

Grazing activity around the South Shetland Islands (Antarctic Peninsula) during summer

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The dilution method was used to estimate phytoplankton growth and mortality by microzooplankton during the austral summer of 2010 around the South Shetland Islands (Antarctic Peninsula). Eight grazing experiments were performed at different stations and yielded values from 0.12 to 0.22 d^{-1} and from 0 to 0.35 d^{-1} of microzooplankton grazing and phytoplankton growth rates, respectively. The proportion of primary production consumed by microzooplankton grazers ranged from 38 to >100%, while the phytoplankton standing stock grazed varied from 7 to >100%. Grazing upon and growth of autotrophic picoeukaryotes (APE) and heterotrophic bacteria (HB) were also analyzed in three experiments. Grazing values ranged from 0.31 to 0.36 d^{-1} on APE and from 0.16 to 0.43 d^{-1} on HB. This grazing activity on APE and HB suggested that, in these waters and at that time, nanoplankton could be the main grazers. Finally, mesozooplankton grazing rates estimated from gut fluorescence data were compared with micro-grazers activity assessed from dilution experiments in order to compare their different impact upon primary producers in these waters.

S6-7063

Three Calanus species populations in the Fram Strait in spring period: Role of hydrological and biological factors

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Fram Strait is a very important region for the Arctic: water from the Arctic Ocean comes through it and meets warm Atlantic water which produces a complicated hydrological situation. Three *Calanus* species, originating from different water masses are present in this area. Copepod *Calanus finmarchicus* is known as a marker of the Atlantic water, *Calanus glacialis* is an Arctic species, originating from the northeast Greenland shelf and *Calanus hyperboreus* is the Polar/Arctic species, originating from Greenland Sea and Nansen Basin. Different reproduction and diapause timing in these species is the key to sustainability of their populations in this area. Warming and ice melting in the Arctic cause the changes in the current system that may affect the *Calanus* complex. Ice conditions are very important in the function of pelagic communities, triggering "blooming" processes in the Arctic. Start of the melting and the duration of ice-free conditions determine the seasonal food web development.

During 2007 and 2008 we investigated the structure of zooplankton community in the Fram Strait in the early spring and summer within the frame of iAOOS Norway project. Zooplankton was collected with the 180 um mesh size net. Samples were taken from different depth strata, beginning with 2000 m depth. We discuss the advection of Atlantic water and ice conditions effect on the zooplankton, compare the population development phases with phytoplankton bloom and examine life strategies for the three Calanus species. In parallel we studied zooplankton communities at different depths in terms of biodiversity and trophic structure.

S6-7142

The metabolic response of Antarctic pteropods (Gastropoda: Mollusca) to food availability

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Zooplankton are integral to the biogeochemical cycling in the Southern Ocean, a region which is responsible for 33% of the yearly global oceanic sink of CO_2. In this biome, zooplankton populations are tightly coupled to the seasonal oscillations in sea ice which correlate with phytoplankton production. Pteropods, an abundant group of pelagic mollusks, are believed to be an important part of carbon export from surface waters and of the food chain in the Southern Ocean. Their potential input to carbon and nitrogen cycling depends on their respiration of O_2 and production of NH_3. Here we quantify these parameters for two prevalent Antarctic pteropods, *Limacina helicina antarctica* and *Clione limacina antarctica,* in response to food availability. We assess food availability both in the laboratory and as a function of the inter-annual variation in phytoplankton biomass, as quantified by remotely sensed chlorophyll *a* throughout the Ross Sea. In comparison to freshly caught animals, *Clione limacina antarctica* which have been held in the laboratory for 4-13 days without food exhibit a ~35% reduction in O_2 consumption. Under the same conditions, *Limacina helicina antarctica* responds with a ~20% decrease in O_2 consumption. The NH_3 excretion of the gymnosome *Clione limacina antarctica* dropped by ~55% during this period, whereas there was no change in the production of NH_3 by *Limacina helicina antarctica*. The available data suggest a reduction in *Limacina helicina antarctica* metabolic rate at lower mean chlorophyll *a* concentrations in the Ross Sea, similar to reductions observed with food deprivation in the lab. Such changes in metabolic rate may strongly impact trophic dynamics and alter biogeochemical cycles of this pelagic ecosystem.

S6-7145

Macrozooplankton rather than *Calanus* are responsible for autumn DVM in Arctic fjords and pack ice: Backscatter contribution by net samples compared with acoustics

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Diel vertical migration (DVM) of arctic marine zooplankton has previously been shown to be a general characteristic of Polar waters throughout the year. Despite the fact that the DVM patterns are well documented, very little knowledge exists as to which species are performing the DVM at different times of the year. Herein we report on an autumn sampling campaign at four different locations around Svalbard using a combination of net sampling and 36 hr mooring deployments with 300kHz ADCPs. DVM patterns were strong but differed among the locations in terms of both backscatter strength and migration characteristics such as speed, number of scattering layers and depths to which the organisms migrated during day. Based on the net sampling, the most important contributors to the observed DVM signals at the three fjord locations were chaetognaths, *Thysanoessa* spp. and *Themisto libellula*. At the station in the pack ice, zooplankton abundance was generally low, but *Metridia longa* together with chaetognaths and *Themisto libellula* were most dominant. In order to relate net samples to the acoustics, a theoretical backscatter and target strength for each of dominant zooplankton taxon were calculated. Previous studies have implicated the later developmental stages of *Calanus* spp as responsible for the early autumn migrations. However, calculations of relative target strength showed that even when *Calanus* were found to be aggregating at depth with abundances up to 300-600 ind. m^{-3}, their contribution to the overall backscatter was many orders of magnitude lower than that of *e.g. Thysanoessa* spp. Hence, previous reports of acoustically detected DVM during autumn were probably also due to macrozooplankton migrations.

S6-7173

Effect of sea ice conditions on physiological maturity of female Antarctic krill (*Euphausia superba*) west of the Antarctic Peninsula

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Physiological maturity stages (PMS), distribution, and total length of female Antarctic krill were examined in the Palmer Long-Term Ecological Research (LTER) study region from 1993-2000. The percentage of females reproducing varied from 10-98%. Distribution data suggested that immature females and females at early reproductive stages are found on the inner shelf, and those at more advanced reproductive stages on the outer shelf. PMS composition for each year was used to characterize reproductive seasons based on timing of spawning, percentage of females reproducing, and percentage of females recycling the ovary. Sea ice extent and timing of retreat were used as a proxy for spring food availability. “Good” years had high spring sea ice extent and initial sea ice retreat in early spring (late September). “Poor” years had low spring sea ice extent or initial retreat earlier or later than the early spring. The predictability of good and poor reproductive seasons based on these sea ice parameters suggests that reproductive effort by Antarctic krill is a function of spring food availability and implies a strong coupling between sea ice conditions in the spring and the physiological maturity of female Antarctic krill the following summer. The overlap in the lengths of immature and mature females suggests that female krill are able to delay maturity and first spawning for up to several seasons if environmental conditions (*i.e.* food supply) are not conducive to reproduction. Females that have reproduced in previous seasons also may skip a season if conditions are poor.

S6-7180

Abundance, structure and biomass of *Calanus hyperboreus* in the Barents Sea

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Although the large copepod *Calanus hyperboreus* can comprise a significant fraction of the mesozooplankton biomass on Arctic shelves, it has received less attention than more abundant species. We studied temporal variability in the quantitative distribution and age structure of *C. hyperboreus* from the southwest (1959 -1993, 2008-2009) and northern (1983-1992, 2002-2009) Barents Sea. Concentration of copepods fluctuated considerably, achieving maximum values at the northern stations of the sections (up to 10-15 ind. m^{-3}). Despite widespread occurrence, *C. hyperboreus* formed densest populations in the central and eastern areas of the Sea, and in the north-central part of the Sea in August-September of moderate and cold years (1984, 1987, 1989). Here in the cold 1987 the species was distributed mainly in the upper layers (50-0 and 100-50 m) as copepodite stage CIV. In warmer 1984, there was a higher percentage of stage CV and females in the entire area that were distributed more uniformly from surface to bottom. The biomass of *C. hyperboreus* reached 70-80 mg WW m^{-3} (up to 50% in the lower layer) in 1984, and 35-40 mg m^{-3} (more than 60% in the upper layers) in 1987 in the northeast. In moderate 2002, biomass was 80-130 mg m^{-3}, and in warm 2006 it reached 370-390 mg m^{-3}. In warm 2009, this species accounted for 20-50% of the total mesozooplankton biomass. This increase in biomass proportion of *C. hyperboreus* under warming conditions is unexpected and suggests more complicated drivers of population dynamics than previously believed.

S6-7189

The occurrence of eugregarinid protozoan within the digestive tract of the Antarctic coastal krill *Euphausia crystallorophias*

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The gregarines are a group of Apicomplexan protozoa. They are typically extracellular parasites of the digestive tract and body cavities of many invertebrates. The eugregarinid protozoan, *Cephaloidophora pacifica* Avdeev (Order Eugregarinorida, Family Cephaloidophoridae) has previously been found in the digestive tract of Antarctic krill, *Euphausia superba*. Their heavy infections in the mid-gut gland are pathogenic and significantly compromise host nutrition. Therefore, their parasites have the potential to physiologically harm the host causing reduced growth. Two Antarctic euphausiid species, *E. superba* and ice krill *E. crystallorophias,* often overlap in distribution in Antarctic coastal regions. There were reports on infestation of *E. superba* and *E. crystallorophias* by ecto-parasitic ciliates belonging to *Ephelota* and *Apostomatidae*. Here, two eugregarinid parasites (endo-parasite) were found in the digestive tract of *E. crystallorophias*. The objectives of the present study are to examine the distribution pattern of the two parasites and to analyze possible factors with respect to variation in each eugregarine infection in ice krill. Recently, studies of small subunit ribosomal DNA (SSU rDNA) proved to be highly informative for phylogenic studies and species identification. Sequences of SSU rDNA have also been used extensively to examine the phylogenetic relationships among apicomplexan parasites. We also present results of sequence analysis of SSU rDNA to determine phylogenetic relationship between eugregarines from *E. crystallorophias* and other gregarine and apicomplexan parasites.

S6-7197

Changes in the production and distribution of Arctic *Calanus* spp. congeners at multi-decadal scales in response to climate warming

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A weight structured population model describing the ontogenetic development including an explicit and generic representation of metabolic reserves has been developed for the dominant *Calanus* species (*Calanus glacialis*, *Calanus hyperboreus*) of the Arctic. Recent experimental data sets on eco-physiological parameters are used to set and calibrate the zooplankton population model. Lipid storage is an important feature that allows the dominant *Calanus* congeners to overwinter in diapause at depth and to anticipate recruitment as “capital breeders” before the start of the spring bloom in the marginal ice zone. Hence, the population model relates dynamically the effect of metabolic constraints at the individual level to the inter-annual variability in life-historical traits (ontogenetic migration, survival and reproduction) that influence secondary production. An investigation into the ability of Arctic *Calanus* spp. to maintain itself under scenarios of decadal to multi-decadal trends of temperature increase is presented. Therefore the population model is coupled to the SINMOD ecosystem model and forced by future atmospheric climate scenarios provided by the regional climate model REMO.

The impact of physical and trophic conditions upon seasonal and spatial changes in production and distribution patterns of Arctic *Calanus* spp. at decadal to multi-decadal time-scales will be discussed. The relative importance of different physiological constraints (*i.e.* feeding, metabolism) on the reserve dynamics influencing reproduction, timing of development and survival will be presented.

S6-7225

Assembling pan-arctic patterns of zooplankton abundance

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We assembled zooplankton data from a wide variety of sources and designed a predictive ecological niche model for the Arctic Ocean using ArcGIS. The model was employed to map the summer-time distribution and abundance of the three dominant arctic endemic copepod species (*Calanus hyperboreus*, *C. glacialis*, and *Metridia longa*) plus a Pacific species (*M. pacifica*) and an Atlantic species (*C. finmarchicus*) that are seasonally expatriated into the Arctic. We pooled data regardless of year, then overlaid observed abundances with climatological environmental data (*e.g.* salinity, water temperature, bathymetry, ice cover, etc.) to predict species-specific abundances throughout the Arctic Ocean. In some regions with rich data sets, predictive performance by the model was high, whereas in regions with sparse data, predictive skills were low. Patterns related to distance from advective gateways, water depth and distance from the continental shelf are presented. Future efforts will continue the process of data consolidation such that decadal patterns in zooplankton abundance can be explored, as well as examining future climate change scenarios.

S6-7250

How did the Arctic amphipod *Themisto libellula* cope with high Atlantic water masses input? A 5 month survey in Kongsfjorden

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The Kongsfjorden, a fjord located on the west coast of Spitsbergen (79ºN), was subject to an exceptional advection of Atlantic water in 2007. A weekly survey conducted from May to September 2007 allowed us to follow the growth and lipid content of a typical Arctic species, *Themisto libellula*, together with its environmental parameters. This pelagic amphipod represents a key link in the food web as an energy pathway from herbivorous copepods to higher trophic levels such as fish, seabirds and marine mammals. Comparison with other samples collected the previous year and in a fjord further north revealed that during 2007 in Kongsfjorden *T. libellula* did not accumulate lipids, however growth rate remained unaffected. This led to different hypotheses concerning its success in the Arctic, but also regarding the potential impact for higher trophic levels through trophic cascade. The fatty acid composition revealed the potential for preferential accumulation of some highly energetic compounds, suggesting a certain degree of flexibility and adaptations to survive the Atlantic influence. In addition, the permanence of *T. libellula* in the Kongsfjorden despite the unusual environmental conditions was intriguing and could insinuate that fjords are used as nursery for juveniles and sub-adults of this species. Indeed there was both a high mesozooplankton biomass relative to their needs and a low predatory pressure constituting the two characteristics of the ideal nursery.

S6-7296

Inter-annual variability of the planktonic communities in the Northeastern Chukchi Sea

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The planktonic communities of the Northeastern Chukchi Sea were examined as part of a multi-year, interdisciplinary study supported by ConocoPhillips, Shell Exploration and Production Company and Statoil. We sampled two neighboring 30 x 30 NM grids (Klondike and Burger) at high spatial resolution three times per ice-free season in 2008 and 2009, with a third grid added in 2010. Chlorophyll *a*, macronutrients and zooplankton (150 µm and 505 µm mesh nets) were collected at 25 stations within each grid. In 2009, the ice retreat and spring bloom were earlier, concurrent with warmer sea surface temperatures over the region than observed in 2008 or 2010. Multivariate analysis demonstrated temporal evolution of the zooplankton community in each year, but with clear differences between years. Interestingly, although seasonally-averaged abundances and biomass were relatively similar between years, differences in the timing and magnitude of key species was of consequence to higher trophic levels. In total, 76 taxonomic categories of holoplanktonic zooplankton were observed, with the greatest taxonomic diversity observed in the copepods (20 species), followed by cnidarians, with significant contributions by meroplankton to both abundance and biomass. In general, the species dominating this region during the ice-free season are largely of Pacific origin, consistent with observations spanning nearly 80 years.

S6-7300

Broadscale patterns of summer zooplankton communities in the Chukchi Sea during 2004 and 2009

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The Arctic's highly productive Chukchi Sea shelf may be particularly sensitive to climate change. Zooplankton communities were examined in the Arctic waters between Alaska and Russia from the Bering Strait northward to Wrangel Island during 2004 and 2009 by the RUSALCA program. A total of 64 holoplanktonic species of Pacific and Arctic origin were encountered, as well as a wide variety of meroplankton that contributed significantly to community abundance and biomass. Total abundance and biomass of holozooplankton averaged 3500 ind m^{-3} and 42 mg DW m^{-3} in 2004, and 8250 ind m^{-3} and 78 mg DW m^{-3} in 2009. Copepods (34 species) made up the bulk of both abundance (88-93%) and biomass (61-71%), while larvaceans, chaetognaths, cnidarians, ctenophores and amphipods also made significant contributions. Multivariate analysis identified several major assemblages of zooplankton, each tied to the physical properties of the water masses present. The distribution of community types showed some similarity between years, but in 2004 the cross-strait patterns were much more distinct. Retrospective analysis and future RUSALCA cruises aim to determine if long-term shifts in zooplankton communities are ongoing in this region.

S6-7308

Feeding habits and life strategy of *Oithona similis* in Kongsfjorden (Spitsbergen): Insights from its lipid content

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In the Arctic, lipids play an important role in the life strategies of marine organisms. Small copepods are often considered opportunists and little is known about their adaptations to polar regions. Among them, *Oithona similis* (Cyclopoida) is distributed worldwide and highly abundant in the Arctic. We present the lipid class composition of *O. similis* and fatty acids and alcohols description of the separate lipid classes over the course of 2 consecutive productive seasons in 2006 and 2007. *O. similis* accumulated long-chain wax esters mainly during the summer (up to 54% of total lipids). The fatty alcohol 20:1ω9, typical of polar adapted copepods, often dominated and could have a dietary origin, although *O. similis* may biosynthesize it by elongation and reduction of the highly abundant 18:1ω9 fatty acid. Diverse food sources have been identified from fatty acids trophic markers in neutral lipids, including diatoms in spring and (dino-)flagellates in summer. Interestingly, odd and branched fatty acids of bacterial origin were significantly recorded, and were maximal in autumn. These could be linked to detritital feeding or most probably to ingestion of bacterivorous ciliates. Based on these findings the modalities of *O. similis*'s adaptations to the Arctic and its sensitivity to environmental changes will be discussed.

S6-7310

C, N, and P body concentrations and ratios in high latitude calanoid copepods: A reflection of changes in environmental conditions?

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Calanoid copepods represent the major part of the secondary producer biomass in all Arctic seas. Their unique life strategy is characterized by an efficient lipid synthesis as a result of adaptation to their environment. They have, as a consequence, more variable body C, N, and P body concentrations and stoichiometric ratios compared to copepods from lower latitudes. These body element concentrations and ratios can vary according to different parameters such as species, development stage, feeding history. We investigated the C, N, and P body concentration and ratios in relation to environmental changes of the two most common calanoid copepods in high latitudes: *Calanus finmarchicus* and *Calanus glacialis*. In a first study, changes in C, N, and P body concentrations and ratios of *C. finmarchicus* were followed over a course of a spring bloom in a north Norwegian fjord. Results showed that C, N, and P body concentrations and ratios of the species are a function of development stage and environmental conditions. In a second study, an experimental approach was used on the Arctic species, *Calanus glacialis*. Organisms were starved and exposed to different temperature treatments over 20 days. Starvation showed an effect on C, N, and P body concentrations and ratios, particularly body carbon, whereas temperature did not have any significant effects. This work gives new insight into potential stoichiometric change in calanoid copepods in relation to environmental changes such as climate induced.

S6-7323

The Arctic Ocean Diversity (ArcOD) data-portal: Zooplankton

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One the greatest hurdles in understanding ongoing changes in Arctic planktonic communities is the fragmented nature of existing information and the general inaccessibility of much of it. During the Census of Marine Life, the Arctic Ocean Diversity project made considerable efforts at consolidating existing datasets and rescuing historical records from both reports and handwritten notes. At present more than 2 dozen datasets containing >200,000 records are online, with more in the processing stream. The continuing aggregation of data will form the foundation for analysis of trends over time. It also represents a centralized location for more regular assessment of patterns and trends at both the region and pan-arctic scale as proposed by the Arctic Council's Circumpolar Biodiversity Monitoring Program (CBMP). This poster summarizes the temporal and spatial extend of the existing datasets, locations of recent sampling activities, and indicates where gaps in knowledge need to be filled. It also solicits additional data contributions.

S6-7330

Are Antarctic krill fecal pellets exported or recycled?

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We sampled 40 schools of *Euphausia superba* from the Scotia Sea in spring, summer and autumn, and found that all aspects of their food processing and defecation varied greatly. For example, pellet C content was 2.3-28% of dry mass and C egestion rates ranged 110-fold. C:N mass ratios of pellets ranged from 4.9-13.2 (median 7.8), higher than the ratios of 3.9 in the krill and 5.4 in the ambient food. Pellet potential sinking rates were 27-1218 m d^{-1} (median 304 m d^{-1}), governed mainly by pellet diameter (80-600μm) and density (1.042-1.490 g cm^{-3}). Low egestion rates equated to long gut passage times and efficient nutrient absorption. This produced compact, fast-sinking pellets with low C content. Conversely, high egestion equated to fast gut passage, inefficient absorption and C-rich, slow-sinking pellets. Food quality had a further effect: diatom diets led to fast sinking pellets, likely ballasted by silica. So depending on how krill process food, their pellets could represent both vehicles for rapid export and slow sinking "point sources" of nutrient-rich food for pelagic detritivores. C egestion rates by krill averaged 3% of summer primary production, so whatever the fate of the pellets, krill are a significant re-packager within the food web. While salp pellets generally sink faster than those of krill, it is the latter that tend to prevail in Southern Ocean sediment trap catches. We suggest that this is because krill schools are more compact, producing "rain showers" of pellets, swamping the ability of detritivores to reprocess them.

S6-7331

Spring blooms in the Southern Antarctic Circumpolar Current Front (SACCF) support early spawning of Antarctic krill

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We measured krill condition, maturity and food processing across the Scotia Sea in November 2006. Near the ice edge, ambient chlorophyll *a* concentrations were low, krill had low lipid reserves (~6.5% of dry mass, DM), low mass:length ratios (~1.7 mg mm^{-1}) and small digestive glands (~7% of DM). There was a bloom 500 km north at the SACCF, and here krill were in better condition (lipid ~10% of DM, weight:length of ~2.2 and digestive glands ~16% of DM). Stomach content and fatty acid (FA) composition indicate feeding on diatoms. At stations further north, moderate food concentrations coincided with moderate condition indices. Only in the SACCF bloom had mating started, with some females ready to spawn. Comparing the FAs in the ambient seston and krill fecal pellets, we found that 20:5(n-3) and 22:6(n-3) were highly retained by krill at the ice edge whereas in the bloom they were not, with instead the efficient absorption of FAs needed for yolk production [*e.g.* 14:0 and 16:7(n-1)] having priority. Krill appeared to be feeding superfluously in the bloom, with fast throughput and low absorption of abundant PUFAs to maximise uptake of those FAs that were required specifically. Successful krill spawning is often suggested to rely on ice-associated blooms. However, we show that the early spring blooms in SACCF are common and indeed are where krill larvae concentrations are highest. We suggest that such blooms, associated with iron fertilisation rather than with sea ice processes, might be major spawning grounds for krill.

S7 Posters

S7-6881

Feeding performance of the copepod *Clausocalanus lividus* (Frost and Fleminger, 1968)

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Clausocalanus is a circumglobally distributed small-sized copepod genus, which can account for a significant fraction of the copepod assemblage in many of the ecosystems it inhabits. In spite of its acknowledged ecological importance and unique motion/foraging strategy among planktonic copepods, many of the biological mechanisms of this genus still remain understudied. This work aims to add information on the feeding performance of *Clausocalanus*, targeting one of the larger congeners, *C. lividus*. Exploiting the spring-early summer population of *C. lividus* in the neritic waters off Barcelona (NW Mediterranean), we investigated the functional response of feeding of wild females on seven single-species diets. The selected prey included an ESD (equivalent spherical diameter) spectrum of 4-28 µm, and with differing motility. Consumption was significant for all the prey, except for the smallest food item offered (*Isochrysis* sp.) which seemed to be at the lower threshold of particle capture by *C. lividus*. A type II functional response was typically exhibited, with the critical concentration for satiation decreasing as the prey size increased. Maximum clearance rates (10 to 308 mL cop^{-1} day^{-1}) also appeared to be associated with prey size, increasing with an increasing ESD. Maximum daily carbon intake ranged from 54 to 137% of body carbon, and was generally higher on prey with ESD >15 µm. Estimated threshold food concentrations, at which basal metabolism of *C. lividus* would be satisfied, appeared relatively high compared to what would be experienced in natural oligotrophic environments.

S7-6882

Protein and nucleic acid metabolism as proxies for growth and fitness of *Oithona davisae* early developmental stages

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Despite the abundance of the marine copepod genus *Oithona*, little is known about its ecology and metabolism, especially regarding its early developmental stages. In this work, we combined two biochemical indices, already used in calanoid copepods, to estimate growth and fitness of *Oithona davisae* nauplii and copepodites: i) the specific aminoacyl-tRNA synthetases (spAARS) activity (proxy of protein synthesis rate) and ii) the RNA/DNA ratio (indicative of overall metabolic activity). We provide a first insight into the variability of these parameters on *O. davisae* nauplii growing under different conditions. The RNA/DNA ratio was more sensitive to starvation than the spAARS activity. We observed a single exponential correlation between spAARS activity and somatic growth rates for nauplii and copepodites. However, the relationship between the RNA/DNA ratio and both somatic growth rates and spAARS activity were different for nauplii and copepodites. The methodological development presented here would simplify the study of small copepod nauplii physiology.

S7-6894

Nucleic acids and protein contents as proxies for protein-specific growth of *Artemia salina*

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Nucleic acids and protein contents have been reported as indicators for growth and nutritional condition of marine copepods over the last decade. These biochemical methods can be applied globally to assess *in situ* growth rates of zooplankton communities, because not only the measurements are simple and rapid, but also the protocols can be widely applied across taxonomic groups. Here we report the nucleic acid and protein contents during the development of a planktonic crustacean, *Artemia salina*. Individual DNA content showed an exponential increase with development stages and time. RNA and protein (PRO) contents slightly declined or were stable over early life stages and development. Individual RNA content was considerably higher for the first naupliar stage just after egg hatching than the other stages. RNA:DNA and RNA:PRO ratios declined or remained stable for a few days after egg hatching, and then exponentially increased. Protein-specific growth rate was significantly correlated with the RNA:DNA and RNA:PRO ratios (Pearson correlation, $p<0.01$). Protein-specific growth rate could be fitted with non-linear regression equations, and saturated at the higher ratios. However, weight-specific (dry mass) growth rate showed no significant correlation with the RNA:DNA and RNA:PRO ratios. These results indicate that RNA:DNA and RNA:PRO ratios are closely associated with nucleic acids and protein syntheses but not dry weight specific growth. We suggest that RNA:DNA and RNA:PRO ratios are useful proxies for protein-specific growth but do not reflect dry weight specific growth.

S7-6903

The R/ETS ratio: Where we are now

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The relationship between respiration and the activity of the electron transport system (ETS) has been intermittently studied over the last 40 years. Yet this is still an unresolved issue requiring greater understanding, because measuring ETS activity or its equivalent, potential respiration, is the fastest and most synoptic way of assessing respiration in ocean space. Furthermore, this topic is an entry point to the understanding of respiratory control, which is currently thought to be accomplished by ADP limitation. Since the research of Peter Mitchell it has been known that this type of respiratory control is not stoichiometric. Substrate control of respiration by pyridine nucliotides (NADH and NADPH) offers the needed reaction stoichiometry, is well understood, and can be used, fairly accurately, to model respiration. Here we present our progress in both the field and laboratory in measuring and interpreting the R-ETS relationship. We review measurements made on different size classes of marine zooplankton from many different oceanographic areas (Central Atlantic, North Pacific, Canary Islands, Baltic Sea, and Antarctica) and on a spectrum of species from 5 phyla of zooplankton and additionally protozoans and bacteria. We show that the variability in the relationship is associated with organism size, physiological state, nutritional state, circadian rhythms, and temperature. Respiration appears to be the more sensitive variable. ETS, because it is constitutive, appears more conservative.

S7-6906

Zooplankton secondary production models in cultures of *Daphnia magna*: A comparison study

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Modeling secondary production rates in zooplankton is essential for population ecology studies, yet assessing these rates is difficult, indirect, and poorly known to the general ecology community. Here we test several secondary production models in cultures of *Daphnia magna*. *Daphnia* were cultured under three different nutrition regimes (food supplied as yeast, corn flour and a heterogeneous culture of phytoplankton). Time-course experiments were performed monitoring biomass and organism size to calculate growth rate and secondary production. Growth was exponential for both Body size and Body mass for each type of food. In the mass-based growth curves the highest growth rate (0.317 d^{-1}) and the maximum individual size were attained for organisms fed yeast. The highest secondary production was obtained with organisms fed on phytoplankton (508.88 $\mu gDM \cdot d^{-1}$) while the lowest was obtained with the organisms fed on yeast (307.46 $\mu gDM \cdot d^{-1}$). We compared our secondary production and growth rate measurements to those predicted from several empirical models (Huntley and López, 1992; Hirst and Sheader, 1997; Hirst and Lampitt, 1998; Stockwell and Johansson, 1997; Shuter and Ing, 1997). The expression of Shuter and Ing ($P=10^{(\alpha+\beta T)}\cdot B$) was the most successful model for secondary production. However, because the other models were unsuccessful, we conclude that caution should be taken when using these models to calculate secondary production.

S7-6907

Experimental evidence that sustained and environmentally realistic diatoms bloom conditions may lead to a decrease in the reproductive fitness of copepods

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Diatom blooms may compromise copepod reproduction, particularly in highly productive upwelling ecosystems where these algal aggregations are a common or even dominant feature of pelagic food webs, by affecting phytoplankton diversity and hence food quality. We found ingestion rates (*IR*) and reproductive performance (egg production rates and hatching success, *EPR* and *H* respectively) of *Calanoides patagoniensis* (Copepoda, Calanoidea), were quickly and significantly affected during a short-term *Thalassiosira rotula* bloom simulation. Although diatoms represent a large carbon and nitrogen source, high food concentration associated with diatoms bloom may complicate food intake, judging by the low clearance and *IR* on this algae. While sustained conditions of diatom-based food did not affect *H*, *EPR* declined reducing fecundity by 40%. Relatively low assimilation efficiency of *T. rotula* was time-independent and negatively correlated with *EPR*, suggesting nutrients were not destined to reproduction under diatoms bloom simulation. Nutritional status of females and eggs derived from diatoms, suggest both stages were healthy and there was not limitation of reproduction-linked proteins. Intense electrophoretic bands at 56kDa in these preparations would reflect the expression of detoxifying CYP1A-like proteins in response to likely reactive *T. rotula* metabolites, re-allocating nutrients and inducing an indirect resource limitation to reproduction. Further proteomic analysis oriented to identify and quantify specific proteins, such as those reproduction-linked or anti-apoptotic, will improve our understanding about physiological and biological consequences to marine copepods facing sustained conditions of diatom-based food in the field.

S7-6916

Absorption efficiencies and basal turnover of carbon, nitrogen and fatty acids in *Calanus* spp.

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Stoichiometric theory can provide insights into the factors controlling an organism's growth. It is underpinned by substrate utilisation efficiencies that relate to key physiological processes such as absorption efficiencies (AEs) and biomass turnover. These parameters are seldom investigated. We used a 5-day food deprivation experiment to investigate basal turnover rates of biomass carbon, nitrogen and essential polyunsaturated fatty acids (PUFAs) and the effect of short-term fasting on nitrogen isotope signatures in *Calanus* spp. We also fed diatoms to *Calanus* spp. and compared the elemental, fatty acid and isotopic composition of their faecal pellets to that of their food, providing insights into AEs and digestive isotopic discrimination. Starvation-induced losses of carbon, nitrogen and PUFAs demonstrate that homeostatic organisms must ingest all of these substrates in substantial quantity to achieve positive net growth. We found no evidence for nitrogen fractionation in copepod tissues during starvation. This supports the suggestion that dissimilatory protein pathways in marine crustaceans are non-discriminating. Gut AEs typically followed the sequence: PUFA > nitrogen > carbon, although low AE for the PUFA 22:6(n-3) was a notable exception. Egested material was significantly depleted in ^{13}C and ^{15}N relative to the ingested food. We attribute this to isotopic discrimination at the macromolecular level, indicating that food quality contributes to the isotopic signature of a consumer organism. The significant basal turnover rates and variable AEs for essential PUFAs and nitrogen demonstrate that organisms cannot be assumed to utilise all nutritious substrates with the same, high efficiency, even when scarce in the diet.

S7-6939

The effect of starvation on respiratory metabolism in *Leptomysis lingvura*

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Mysids are mid-sized planktonic crustaceans present in many coastal regions of the world ocean. *Leptomysis lingvura* is found along the east coast of Gran Canaria (Spain), associated with the sandy bottom, and living at depths between 5 and 15 metres. *L. lingvura* is an important component in the food chain as food for many coastal fish, and could be a potential live prey for aquaculture. We studied their survival and reproduction in captivity to determine their suitability for physiological and biochemical research in the laboratory. They proved to adapt well to aquarium life, and to be highly suitable for studying respiratory metabolism. The present study was designed to document the effect of food deprivation on respiration at the physiological and enzymological level. The research strategy was to follow a simple time course of both the oxygen consumption rate and the activity of the respiratory electron transport system (ETS). Respiration (R) decreased logarithmically during starvation, whereas the ETS activity remained constant. As a consequence, the ratio of R to ETS activity decreased along with the respiration. Superimposed on the declining respiration rate was an unforeseen diel rhythm that elevated R during the light, and depressed it during the dark.

S7-6953

Reproducing planktic foraminiferan growth, habitat and abundance using an ecophysiological multispecific approach

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We present an eco-physiological model reproducing the growth of 8 foraminifera species based on different ecophysiological experiments. By reproducing the main physiological rates of foraminifera (nutrition, respiration, symbiotic photosynthesis), this model estimates their growth as a function of temperature, light availability and food concentration. The growth rate estimated from the model shows a positive correlation with the observed abundance from plankton net data, suggesting a close coupling between individual and population growth rates. This observation was used to directly estimate potential abundance from the model-derived growth. Using satellite data, the model predicts the dominant foraminifer with a 70.5% efficiency when compared to a data set of 576 field observations worldwide. Using outputs of a biogeochemical model of the global ocean (PISCES), instead of satellite images, as forcing variables also gives good results, but with a lower efficiency (58.9%). The model also correctly reproduces the relative abundance of the eight species worldwide, with only a 3-19% root mean squared error (RMSE) between core top observations and model results using satellite images, or 3-23% RMSE using the PISCES model as input. The diversity pattern is also correctly reproduced. This model allows prediction of the season and water depth at which each species have its highest growth potential. This offers promising perspectives for both an improved quantification of paleoceanographic reconstructions and for a better understanding of the foraminiferan role in the carbon/carbonate ocean cycle.

S7-7011

Reproductive performance of *Oithona davisae* (Copepoda, Cyclopoida) feeding on different concentrations of the heterotrophic dinoflagellate *Oxyrrhis marina*

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We have investigated the effect of food concentration on the egg production of the cyclopoid copepod *Oithona davisae*. A cohort of copepods was grown in the laboratory, and when the C5 stage was reached, the cohort was split into "subcohorts" and conditioned to different concentrations of the heterotrophic dinoflagellate *Oxyrrhis marina* (50 to 1200 cells ml^{-1}). We kept these "subcohorts" under the same food conditions for 15 days, and checked the number of ovigerous females and the average clutch size daily. Both the time for the first appearance of ovigerous females and their proportion in the cohort were dependent on food concentration. Clutch size also differed among food concentrations. In addition, to assess the efficiency of conversion of food intake into egg mass (analogous to the gross-growth efficiency for somatic growth), two functional response experiments were conducted to determine feeding rates of the adult females.

S7-7020

Critical stages of nauplii growth: Is the early development determined by maternal reserves or initial feeding?

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Food quantity and quality can control development and mortality rates of copepods. However, the effects for early nauplii stages can partly be compensated by maternal effects through egg quality. It is not clear how the effects of egg quality compares with those of food quantity/quality experienced by the nauplii. We therefore investigated the proportional effects of egg quality vs. feeding for different nauplii stages of *Temora longicornis* when experiencing starvation or different degrees of qualitative food limitation. 'Good' and 'bad' eggs were produced by growing the maternal generation under optimal food conditions or by inducing a qualitative food limitation and crowding, respectively. The nauplii originating from 'good' and 'bad' eggs were offered *Rhodomonas* sp. (good quality food), *Tetraselmis suecica* (intermediate quality) or *Dunaliella* sp. (poor food), either directly after moulting (starting with NI), or after different periods of feeding on optimal food (starting with NII, NIII-IV and NV-VI). Our results show that: 1) egg quality has a small but significant effect on nauplii survival and development under sub-optimal food conditions, 2) nauplii originating from good eggs have a higher starvation tolerance, and 3) feeding can compensate for the effect of bad eggs if nauplii are offered good quality food, although gross growth efficiency of nauplii originating from bad eggs are lower. The maternal effects persist when experiments are started with NI-II, but disappear if the qualitative food limitation is first introduced from NIII stages onwards. We suggest that these effects, although small in an individual scale, can accumulate into substantial effects at a population scale.

S7-7097

Factors controlling the seasonal dynamics of fecundity and recruitment of *Temora longicornis* in the Baltic Sea

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Factors controlling the seasonal dynamics of the individual body size, egg production (EP) and recruitment of *Temora longicornis* in the western Baltic Sea (Bornholm Sea) were studied over 1.5 years in 2002/2003. Individual egg production varied between 0 and 29 eggs fem^{-1} day^{-1}. Egg production rates (EP) were very low in winter, followed by maximal rates in spring associated with the spring phytoplankton bloom, at still low water temperatures. The post-bloom, summer and autumn egg production rates was again moderate to low. The seasonal cycle in EP largely reflected variation in food concentration and body size. Multiple regression analysis reinforced that food availability, in particular ciliates, dinoflagellates and flagellates, were the main factors controlling egg production rates, followed by body size. Body size, in turn, depended primarily on temperature during the cohort's development. The primary control of EP of Baltic *T. longicornis* by food availability contrast with the observations from other areas, where body mass, suspended matter or temperature were identified as important determinants of EP. The recruitment rate of the population revealed that during late spring and summer, when EP is low, recruitment often equals or exceeds that in spring, when EP is high. Female abundance, therefore, is equally important to EP per female in determining the recruitment of *T. longicornis* in the Baltic Sea.

S7-7117

Absence of substrates underestimates the measurement of electron transport system activity in zooplankton

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Respiratory electron transport system (ETS) activity is a proxy for oxygen consumption in marine communities. Normally, the methodology follows standard practices of enzymology, by assessing the ETS V_{max} by reduction of a tetrazolium salt (INT). However, recently a deviant was developed that omitted the biochemical reactants (substrates) that makes the ETS assay specific for respiration. The rationale was to measure *in vivo* ETS activity and hence *in-situ* respiration. This assay did not use the substrates (NADH, NADPH and succinate) required for the ETS to function. Instead it relied on the sample's cytoplasm to supply these substrates. Unfortunately, dilution during extraction reduces the substrate concentrations far below their *in vivo* levels. Here we examine this zero-substrate method by comparing it to ETS activity measured by standard methods. ETS activity in the marine mysid, *L. lingvura,* was measured by two methods that use substrates and the one method that does not. This latter technique (the zero-substrate technique) displayed weak activity, comparable to the blanks of the standard methods. Was the origin of this low activity the ETS or natural reduced organic substances in the mysid cells? Could ascorbic acid, vitamin-B_{12}, glutathione, cysteine, glucose, and phenol reduce INT to its formazan? We found that ascorbic acid, cysteine, glutathione, and vitamin-B_{12} reduced INT non-enzymatically. Thus their presence in samples will confuse the interpretion of an ETS assay made without substrates. Our results indicate that the zero-substrate method is both insensitive and non-specific, rendering it marginally useful for oceanographic research.

S7-7132

The impact of body size and starvation on the biochemistry and the physiology of ammonium excretion in the mysid *Leptomysis lingvura*

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The importance of ammonium (NH_4^+) excretion to the physiology of planktonic crustaceans, the relevance of remineralized nutrients to total phytoplankton productivity, and the widespread distribution of mysids in shallow marine waters attests to a significant role for them in the nitrogen cycle of coastal ecosystems. Since accurate quantification of zooplankton excretion rates is difficult because of artifacts associated with the traditional incubation methods, Bidigare and King suggested measuring glutamate dehydrogenase (GDH) as a tool to estimate physiological ammonium formation. This work will present the physiological and biochemical aspects of nitrogen excretion in *Leptomysis lingvura*. Organisms were collected in the shallow waters on the east coast of Gran Canaria and maintained in cultures. With interspecific and environmental interferences minimized, the behavior of NH_4^+ excretion and GDH activity as a function of body size and different food levels was investigated. Physiological NH_4^+ excretion was analyzed according to Kérouel and Aminot, while enzymatic activity was measured spectrofluorometrically through NADH fluorescence determination. Biomass was estimated as protein content in the samples using the Lowry method. During the different levels of food-deprivation, the O:N ratio was studied as an indicator of lipid/protein/carbohydrate composition of the organic matter being oxidized by the mysids. In protein–based phase nutrient sufficiency, there is a strong relationship between NH_4^+ excretion and GDH activity (r^2=0,871). The change in this relationship in starved mysids will be presented and discussed.

S7-7133

Role of pyridine nucleotides in controlling the respiration of the dinoflagellate *Oxyrrhis marina*

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Presenter: Ted T. Packard on behalf of Natalia Osma

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Respiration is a measure of oxygen consumption (R_{O2}) catalyzed by the respiratory electron transport system (ETS) enzymes. The physiological R_{O2} rate depends directly on the enzymatic control of the respiratory ETS activity. We argue that substrate availability is the most quantitative regulatory mechanism controlling this activity. The ETS substrates are the pyridine nucleotides (PNs) and succinate, but the PNs play the dominant role. Furthermore, the PNs also play key roles in providing reducing equivalents for hundreds of cellular reactions in biochemical pathways. They occur in oxidized and reduced forms as nicotine adenine dinucleotide (NAD^+, NADH) and as nicotine adenine dinucleotide phosphate ($NADP^+$, NADPH). NADH is the preferred form for catabolism reactions and NADPH for anabolism reactions. Up to now, no studies have investigated the intracellular levels and redox states of either PN in marine organisms, despite their history of being widely investigated in biomedicine and in plant and animal physiology. Here, we explore the levels of NAD(P)H and their roles in controlling R_{O2} in cells of *Oxyrrhis marina*, a marine dinoflagellate. To accomplish this objective, cultures of *O. marina* were fed the cryptophyta, *Rhodomonas salina* only at the beginning of the experiment. Afterwards, these cultures were kept without adding any food for the rest of experimental period. Every two days measurements of ETS, R_{O2}, protein and NAD(P)H levels were made. Here the behavior of these parameters throughout the time course of the food deprivation period will be presented and discussed.

S7-7163

Ecophysiology of the naupliar stages of the cyclopoid copepod *Oithona davisae*

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Among marine planktonic copepods, the genus *Oithona* is probably the most abundant and ubiquitous copepod in the world's oceans. However, knowledge about the ecophysiology of oithonids is very scarce compared to calanoid copepods, particularly for their naupliar stages. We determined feeding, growth and respiration rates of the nauplii of *Oithona davisae* in the laboratory as related to food concentration and temperature. Maximum specific naupliar growth rates (0.30 d^{-1}, at 20ºC) were reached at food concentration of 87 µg C L^{-1}. Feeding rates in relation to food concentration followed a type III functional response, with saturation food concentration at 250 µg C L^{-1}. Specific respiration rates of *O. davisae* nauplii increased from 0.24 d^{-1} in absence of food to 0.55 d^{-1} under fed conditions. Ingestion, growth and respiration rates of nauplii increased with increasing temperature with a Q_{10}~2.5 for a temperature range of 16-28ºC. Our results support that the lower food requirements and carbon respiratory losses of *Oithona* compared with calanoids may contribute to explain their success in marine ecosystems.

S7-7179

Seasonal acclimatisation of the respiration rate of *Temora longicornis* (Müller)

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We investigated seasonal changes in the respiration rate of adult *T. longicornis* under *in situ* conditions. Copepod respiration rates started to increase in January, reached the highest values between April and August, and declined to a minimum in December. Multiple regression analysis showed a significant increase in copepod respiration rate with increasing body dry weight (DW), temperature (T), chlorophyll *a* concentration (Chl) and egg production rate (EPR). The exponent of the power functions of *T. longicornis* respiration rate and body DW ranged from 0.82 to 1.03 over the seasonal cycle. The relationship between *in situ* acclimatised weight-specific respiration rate and temperature was described by a sigmoidal trend with rates increasing between 7ºC and 13ºC but remaining relatively constant below and above this range. Our results suggest that seasonal changes in the respiration rate of female *T. longicornis* are not simply controlled by DW and temperature, but reflect the energetic costs associated with the nutritional and reproductive conditions of the copepods.

S7-7242

Species and strain- specific effect of *Skeletonema marinoi* on copepod physiology

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Three strains of the chain-forming diatom *Skeletonema marinoi*, differing in cell volume, C and N content, and composition of fatty acids, sterols and polyunsaturated aldehydes (PUA), where used in experiments on copepod physiology. We used three calanoid species common found in the coastal waters of northern Europe, *Acartia tonsa*, *Pseudocalanus elongatus* and *Temora longicornis,* and quantified feeding, egg production rate (EPR), egg hatching success (HS) and faecal pellet production rate (PP). The different diatom strains induced different effects on ingestion, egg production, hatching and faecal pellet production, but these effects differed between the three copepod species. However, DHA and sterol content of the diet typically showed a positive effect on either egg production (as shown by *A. tonsa*) or hatching success (as shown by *P. elongatus*). Our results demonstrate that differences in cell composition between strains of a given diatom species can generate effects on copepod physiology as large as those induced by different algae species or groups. They also emphasize the need to consider the presence of multiple strains with diverse cell composition in the natural environment, and how this interacts with different copepod species combinations, for instance during a diatom bloom.

S7-7279

Mnemiopsis leidyi feeding response to temperature is size dependent

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The ctenophore *Mnemiopsis leidyi* first appeared in northern Europe half a decade ago. It has since reoccurred in high numbers and biomass every autumn. The individual feeding rate on mesozooplankton is high and scales with ctenophore size. However, in this boreal region, characterized by large temperature variations, the effect of temperature on feeding rate has not previously been investigated. This study quantified the size-specific clearance rate of *M. leidyi* at 3 different temperatures. Clearance rate increased with temperature, but the rate of increase was not constant, rather it varied with ctenophore size. Small ctenophores displayed a lower increase with temperature compared to large ctenophores. The implications of this size-specific temperature difference will be discussed.

S7-7286

Physiological ecology of the diel vertically migrating squid *Pterygioteuthis* sp.

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Numerous diel vertical migrators experience large shifts in oxygen concentrations with depth, spending much of their day in hypoxia. Nights spent in shallower water may be key to meeting oxygen demands for routine activities. The consequences of decreased oxygen availability in near-surface water driven by ocean warming are unknown. We investigated aerobic and anaerobic metabolism in the small diel vertically migrating squid *Pterygioteuthis sp*. Individuals were collected in the Gulf of California, Mexico, where they are important in the diet of the Humboldt squid, *Dosidicus gigas*. Individuals were incubated in normoxia or hypoxia and oxygen consumption rates were recorded using end-point analysis. Citrate synthase activity was measured as a proxy for aerobic metabolic potential, while octopine dehydrogenase activity was measured as a proxy for anaerobic metabolic potential. Lastly, octopine accumulation was measured in individuals to determine the contribution of anaerobiosis to total energy demand.

S7-7289

Effect of temperature, food type and concentration on the grazing and reproduction of the calanoid copepod *Centropages chierchiae*

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Zooplankton plays an important role in the functioning of marine ecosystems, particularly as grazers in ocean foodwebs, representing the main energetic pathway from primary producers to higher trophic levels. In the northern hemisphere, the impact of global warming on zooplankton was shown to manifest as species expanding their distributional range polewards as the seas warm. In particular, the calanoid copepods *Centropages chierchiae* and *Temora stylifera* occurred rarely in the Continuous Plankton Recorder (CPR) survey in the Bay of Biscay, Celtic Sea, and English Channel before 1988, whereas from 2000 they are found frequently and at greater abundance in these areas. For this reason, both are considered to be key species in monitoring climate changes at the northern limits of their distribution. In this work, laboratory experiments were conducted to study the combined effect of temperature and food quantity and quality on the grazing and egg production of the copepod *C. chierchiae*. Experiments were also conducted to study the selective feeding behavior of *C. chierchiae* when offered a mixture of different prey types. Prey included the microalgae *Rhodomonas baltica*, *Scripsiella trochoidea*, *Gymnodinium* sp. *Phaeodactilum tricornutum* and *Dytilum brighwelli*. Ultimately, this work intends to contribute to understanding the impact of temperature and food environment on the *C. chierchiae* population dynamics, and infer the possible impact of its northward movement to plankton communities.

S8 Posters

S8-6905

Zooplankton respiration and vertical carbon flux

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The transport of carbon from ocean surface waters to the deep sea is a critical factor in calculations of planetary carbon cycling and climate change. This vertical carbon flux equals the respiration of all the organisms in the water column below the surface, the respiration of the organisms in the benthos, as well as the carbon lost to deep burial. Accordingly, for conditions where the benthic respiration and the carbon burial are small relative to the respiration in the water column and where plankton respiration dominates the seawater respiration, the carbon flux can be calculated by integrating the vertical profile of the water-column plankton respiration rate.

We have done this in the Gulf of Maine from measurements of microplankton ETS activity, but in that calculation we did not measure zooplankton respiration or its proxy, ETS activity. Here, we use previously published macrozooplankton and microplankton ETS in water column profiles made off the coasts of NW Africa and western Mexico. From them we calculated seawater respiration depth profiles and the mathematical functions that best describe their decline with depth. Then, integrating these respiratory profiles from the respiratory maximum to a deep-water minimum we calculated zooplankton carbon flux profiles for these two regions. The relative merits of these calculations will be discussed.

S8-6915

Comparison of depth distribution of mesozooplankton communities between the subarctic and subtropical Pacific Oceans: Relative importance of vertical migrants to downward carbon flux

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We compared depth distributions of mesozooplankton communities and predominant copepods during winter between the subarctic and subtropical Pacific Oceans to evaluate the relative importance of actively transported carbon by vertical migrants and sinking particulate organic carbon (POC) flux. Copepods were the predominant mesozooplankton taxa in both abundance and biomass from the surface down to 1000m at both sites. At the subtropical site, the highest mesozooplankton abundance and biomass was above 50m during nighttime and from 300 to 500m during day time, indicating diurnal vertical migration. Copepods and euphausiids were responsible for this diurnal vertical migration. Respiratory flux by diurnal migrating mesozooplankton was estimated to be 2.2 mgC m^{-2} day^{-1} at the subtropical site. This estimate was equivalent to 8% of sinking POC flux and exceeded fecal pellet flux measured by drifting sediment traps at 150m. Moreover, dormant copepods expatriated from the subarctic and their carcasses were abundant below 500m. These results suggest that actively transported carbon, which can not be measured by sediment traps, is important. We discuss the functional roles of the mesozooplankton community in the biological pump at both sites.

S8-6919

Relative importance of respiratory carbon flux by *Pleuromamma* copepods in the subarctic and subtropical Pacific Oceans

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We investigated depth distribution and population structure for *Pleuromamma* copepods during winter in the subarctic and subtropical Pacific Oceans to estimate respiratory carbon flux by diurnal vertical migration. *Pleuromamma* copepods were major components of diurnally migrating mesozooplankton during winter at both sites. The predominant species were *Pleuromamma scutullata* at the subarctic site and *P. abdominalis*, *P. gracilis* and *P. xiphias* at the subtropical sites. Based on the weighted mean depths between day and night, diurnal vertical migration was enhanced in adult males and females compared to copepodite stage 5 at both sites. At the subtropical sites, the respiratory carbon flux by *Pleuromamma* copepods at mesopelagic depths was estimated to be 1.58 mgC m^{-2} day^{-1}. This respiratory carbon flux was equivalent to more than 80% of faecal pellet flux by mesozooplankton at 150m. These results suggest that diurnally migrating copepods are important contributors to vertical carbon flux in the subtropical sites. We compare the importance of active respiratory carbon flux by diurnal vertical migrants to sinking particulate organic carbon between the two sites.

S8-6921

The contribution of metazooplankton to carbon flux in waters adjacent to an eastern Indian Ocean coral atoll

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We compared pelagic processes at three (400+ m) stations adjacent to Scott Reef (14°S), a shelfbreak reef in Australia's Indian Ocean territory, to those within the shallow (ca. 50 m) atoll lagoon. The surface mixed layer seasonally varies between 20 and 100m thick, and despite very low phytoplankton biomass, is moderately productive (mean = 62 mmol C m^{-2} d^{-1}). Picoplankton (<2 um) account for most (84%) primary production and euphotic zone respiration rates are also high (mean = 115 mmol 0_2 m^{-2} d^{-1}), resulting in frequent occurrences of net heterotrophy. Consequently, carbon fluxes from the mixed layer to deeper waters are very low (median = 6% of concurrent primary production). The metazooplankton assemblage sampled by our 100µm multinet system was dominated by small copepods, with larvaceans episodically co-dominant in the mixed layer. Redundancy analysis of community structure indicated a distinct mixed layer community, within which the lagoon community was further distinguished by reef-associated copepods. Zooplankton community structure in the upper thermocline (100-300m depth) was distinct from both the mixed layer and the deeper stratum below (300-400m). The copepod family Oncaeidae was highly speciose (>65 taxa) and progressively more important with increasing depth. We demonstrate that larvaceans and small copepods (primarily Paracalanidae and Oithonidae) are important in carbon cycling in the mixed layer of the tropical ocean, but Oncaeidae are by far the most important metazooplankters of the upper mesopelagic.

S8-7039

How significant are allochthonous subsidies for zooplankton production in coastal areas?

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Estuaries and rivers dramatically influence the physical-chemical conditions of coastal oceans through the modification and exchange of organic materials and nutrients. In order to evaluate the potential sources and composition of organic matter across the land-ocean continuum, we characterized particulate organic carbon (POC) using stable isotope ($\delta^{13}C$) and lipid biomarker analyses. Estimates of zooplankton carbon ingestion rates and zooplankton (copepods, euphausiids, and amphipods) $\delta^{13}C$ and $\delta^{15}N$ were also used to evaluate the implications of allochthonous subsidies for zooplankton inhabiting coastal areas. Here, we show results from measurements in the framework of different studies and in contrasting regions along Chilean coast, from coastal upwelling areas in Central Chile to fjord ecosystems in Chilean Patagonia. Preliminary results off Central Chile show that terrestrial carbon may account for a significant percentage of the body carbon (1–63%) for both decapod larvae and copepods. In fjord areas, where terrestrial sources supported around 68–86% of the POC in river plumes and glacier melting areas, estimates of carbon ingestion rates and $\delta^{13}C$ in copepods from these areas indicated that terrestrial sources could account for a significant percentage of the copepod body carbon (20–50%) during periods of food limitation. These terrestrial carbon pathways to zooplankton, as well as the relative allocation of phytoplankton- and terrestrial-derived carbon to their somatic growth and reproduction, have been largely ignored. These findings have significant implications for models of carbon fluxes and food webs in productive coastal ecosystems, which usually only consider the fate of primary productivity to higher trophic levels.

S8-7045

A simple model to estimate active flux in relation to zooplankton lunar cycles in subtropical waters

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Epipelagic mesozooplankton biomass was studied during the late winter bloom in Canary Islands waters. As observed previously, biomass in the productive season peaked around every full moon. This occurs because during the lunar illuminated phase, to avoid predation, diel vertical migrants do not enter the shallower layers (0-100m) of the ocean, while during the dark period migrants are found in these shallower waters. As a consequence, epipelagic mesozooplankton increase in biomass around full moon due to release from predation pressure, and decrease in biomass during the dark phase of the lunar cycle due to consumption by micronekton migrants. In order to model this cycle of predation, a simple equation was used to simulate mesozooplankton biomass during the bloom. The model showed significant correlations between the true and predicted biomass at different growth and mortality rates. The estimated active flux for this period was comparable to gravitational flux. These results indicate that active flux represents an important and unaccounted flux of carbon to the mesopelagic zone in this area.

S8-7052

Variation in nitrogen and carbon isotopes in the Bahía Blanca Estuary: Implications for ecological studies in a human-disturbed system

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Although stable carbon and nitrogen isotopes are widely used in marine ecosystem research, this study presents the first report on their variation in the Bahía Blanca Estuary. Sampling was carried out at stations where human impact was high (Canal Vieja: CV) and low (Bahía del Medio: BM), during both the winter phytoplankton bloom and spring-summer post-bloom period. Surface water, plankton samples, and environmental variable measurements were obtained. Isotopic data were analyzed using a multivariate approach. In winter, $\delta^{13}C$ values varied from -23.98 to -19.706‰ in CV and from -23.389 to -19.09‰ in BM. In summer, $\delta^{13}C$ ranged from-24.83 to -18.66‰ and from -23.43 to -16.20‰, in CV and BM stations, respectively. Generally, in both seasons, $\delta^{13}C$ showed higher variability in consumers in BM than in CV. In winter, $\delta^{15}N$ values ranged from 3.82 to 11.11% in CV and 7.19 to 11.72‰ in BM. In summer, $\delta^{15}N$ ranged between 2.37-16.77‰ and 9.02 -15.19‰ in BM. The $\delta^{15}N$ values indicated food sources varied from the base of the food web to consumers at both stations and in both seasons. Consequently, suspended particulate matter (SPM) and primary producer $\delta^{15}N$ values were slightly higher than consumers. While $\delta^{13}C$ values of SPM, producers, and consumers varied little between stations, $\delta^{15}N$ variability was higher. These preliminary results indicate that stable isotopes are useful indicators of food types and sources, and can be used to study changes in the structure of the planktonic food web caused by anthropogenic impact in the Bahía Blanca Estuary.

S8-7060

Daily ration and feeding chronology of dominant diel vertical migrant fishes in the Subtropical Eastern North Atlantic Ocean

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Diel Vertical Migrants (DVMs) are mainly zooplankton and micronekton that migrate upward from 400-500m depth every night to feed on the productive epipelagic zone, returning to depth at dawn where they defecate, excrete, and respire the ingested carbon. DVMs thus contribute to the ocean's biological pump, and accordingly, to the global CO_2 balance. The lanternfishes (myctophidae) contribute up to 90% of total DVMs biomass. Myctophids may thus represent a pathway accounting for a substantial export of organic carbon to the deep ocean. However, the magnitude of this transport is still poorly known. In order to assess this active flux of carbon, we performed a preliminary study of mesopelagic organisms around the Canary Islands. Here we present the results of diet, daily rations, and feeding chronology of *Lobianchia dofleini*, *Hygophum hygomii,* and *Ceratoscopelus maderensis*, three dominant species of myctophids performing diel vertical migrations in the Subtropical Eastern North Atlantic Ocean. Samples were obtained on board the R/V *La Bocaina* during June 2009. Myctophid stomach contents were studied throughout the diel period. Our results reveal a prevailing nocturnal predation mainly on copepods, euphausiids, and amphipods. The state of digestion of prey indicates a slow stomach evacuation rate, suggesting that most of the ingested carbon in the epipelagic is efficiently transported to the mesopelagic zone.

S8-7078

Influence of the late winter bloom on migrant zooplankton metabolism and its implication for export flux

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Estimates of carbon transported from surface to deep waters due to diel vertical migration are scarce and critical for carbon flux models and biogeochemical estimates. We assessed the temporal variability and vertical distribution of the zooplankton community north of the Canary Islands to determine the vertical fluxes of carbon for this area. Zooplankton community biomass and indices of feeding and respiration were measured during the end of the late winter bloom. A typical pattern of biomass distribution was observed during the day with two dense layers of organisms located between 0-200 m and around 500 m, coincident with the deep scattering layer. At night, all the biomass concentrated in the epipelagic layer. The estimated gut pigment flux (0.05 - 0.18 mg $C \cdot m^{-2} \cdot d^{-1}$) represented 0.22% ± 0.12 of the calculated passive particulate export flux resulting from primary production (POC flux). The estimated active respiratory flux (0.40 - 1.36 mg $C \cdot m^{-2} \cdot d^{-1}$) was only 1.46% ± 0.84 of the POC flux. Using the respiration data we determined a potential ingestion (1.24 – 3.40 mg $C \cdot m^{-2} \cdot d^{-1}$) representing 3.92% ± 1.85 of the POC flux. The total carbon flux (respiratory flux plus potential ingestion) due to the diel migrant community ranged between 3.37 – 9.22% of the POC flux (5.38% ± 2.67), three-fold higher than using the gut pigment flux values. These results suggest that gut and respiratory fluxes by diel migrants play a small role in the downward flux of carbon in the open ocean during the post-bloom period.

S8-7096

Changes in zooplankton population structure during and after the north-western Mediterranean open sea spring bloom

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The northwestern Mediterranean basin is a key biogeochemical area in the Mediterranean Sea. Fertility is enhanced by deep convective mixing in winter and the consequent winter-spring bloom after re-stratification. Primary production calculated from satellite images of this area is estimated to represent more than 15% of the whole Mediterranean, with the spring bloom contributing to most of this production. In the framework of the project FAMOSO we investigated the transfer of this open sea bloom to higher trophic levels by analyzing micro-, meso-, and macrozooplankton communities during key successional stages: pre-bloom- bloom (March), decline - post-bloom (May), and stratification (September). In March a diatom bloom consisting of a typical spring-bloom assemblage developed. We encountered considerable heterogeneity of physical, chemical and biological parameters and used Principal Component Analysis to classify and cluster sampling stations (41 total). During the three stages zooplankton populations differed in biomass, size spectra, and composition. Microzooplankton always exhibited the highest biomass (average of 21.4, 6, and 7 mg dry weight m^{-3}, bloom, post-bloom and stratification, respectively) with highest increase during March. Mesozooplankton biomass was high in March in comparison to the other periods (11.2, 4.9 and 5.1), suggesting water advection from a more advanced plankton successional stage. During the post-bloom stage macrozooplankton was also important, and the stratification period was characterized by lower stocks. Salps contributed significantly to the total population in March and May. These changes in composition and abundance of micro-, meso-, and macrozooplankton are discussed in relation to the environment.

S8-7113

Mesozooplankton growth as measured by enzymatic activity off the Western Australia coast

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The determination of zooplankton growth is essential for the estimation of pelagic productivity, and consequently for our understanding of ocean biogeochemical fluxes. The use of biochemical proxies of zooplankton growth eliminates the necessity of laborious onboard incubations, allowing the estimation of growth and production at spatial or temporal scales not logistically feasible with incubation techniques. In this study, we investigated the interaction of physical processes and zooplankton production using a biochemical proxy of structural growth (the enzymatic activity of aminoacyl-tRNA synthetases - AARS). Epipelagic mesozooplankton was sampled during a cruise in the Austral autumn of 2007 in transects from the coast (50m depth) to offshore (1000-2000m depth) at every latitude from 22°S to 34°S. The biomass (protein), growth (specific AARS activity) and production (community AARS activity) were estimated in four zooplankton size fractions (100-150µm, 150-250µm, 250-355µm and >355µm). Zooplankton biomass, growth, and production were higher inshore than offshore. Growth rates and production of the large zooplankton were positively correlated with small zooplankton, but not with chlorophyll. Biomass, growth, and production of large zooplankton were positively correlated with temperature offshore but were not close to the coast. The AARS technique allowed the identification of a high zooplankton productivity zone at 29-30°S, which appeared to be associated with the deepening of the mixed layer and the production of eddies from the southward flowing Leeuwin Current.

S8-7156

Zooplankton fecal pellet export during spring in the eastern Fram Strait

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A sediment trap was deployed as part of the HAUSGARTEN project at 340 m (78°59′N; 4°27′E; water depth=2568m) from March 25 to July 14 2003 to monitor downward carbon export during spring in the eastern Fram Strait. Samples were collected every 4 days to measure zooplankton fecal pellet and particulate organic carbon (POC) export fluxes at a high temporal resolution. Fecal pellet fluxes remained under 5 mg C m^{-2} d^{-1} during the deployment and the contribution of fecal pellets ranged from 6 to 98% of the POC flux. Fecal pellets fluxes were low at the end of March and in April, increased at the end of May, decreased at the end of June and were low again in July. The proportion of fecal pellets in the POC flux was elevated (>70%) at the end of May and in mid-June. Cylindrical fecal pellets (copepods) dominated the fecal pellet flux in April, in May, at the end of June and in July, while ellipsoidal fecal pellets (appendicularians) dominated the flux during ~2 weeks in June, coinciding with the maximum in fecal pellet export. These results suggest that the expected shift in zooplankton community structure in response to a warmer inflow of Atlantic Water may affect the magnitude and composition of the downward export of biogenic matter in the eastern Fram Strait.

S8-7211

Depth attenuation of organic matter export associated with jelly-falls

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The downward flux of particulate organic matter (POM) sequesters carbon dioxide and redistributes chemical properties in the ocean, ultimately governing the resources fuelling marine benthic ecosystems. Gelatinous zooplankton POM originates in jelly-falls (as carcasses) associated with blooms and has received little attention in observational oceanography and modelling studies. Jelly-POM seabed transfer efficiency from the water column is poor and thus we explored the attenuation in the export flux ratio for gelatinous zooplankton detritus. We present a new mathematical formulation of the jelly-POM export flux ratio [$M_{(z1)}/M0_{(z0)}$] applicable to numerical modeling, constrained by *k* data (decay rate), temperature, and sedimentation rate. The model initial conditions rely on a concept referred to as "death-depth" (governed by the migratory ranges of organisms), thus establishing the starting point of a jelly-fall in the vertical axis. Using WOCE-A16/P16 (Atlantic/Pacific Ocean) transects we developed maps of the predicted $k_{(T)}$ and *t0.01* (remineralization time) from 0 to 6000 m using bathymetry data. Using VERTIGO project data (ALOHA Station) we compare the jelly flux with the Martin curve formulation, with a particle-based parameterization used in biogeochemical models, and sediment trap POM percentage data. We conclude that temperature and sinking speed interact to determine the jelly-POM export flux ratio and that a constant *k* applied in all modeling scenarios or particulate material can be misleading in export flux formulations. The work presented here ultimately allows inclusion of jelly-POM flux ratios in global biogeochemical model formulations.

S8-7248

Zooplankton biomass and indices of grazing, metabolism and growth after a dust deposition event in subtropical waters

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Weekly sampling in the oceanic waters north of the Canary Islands was performed from February to June 2010 in order to study the short-term variability of plankton. Here we report the results of mesozooplankton biomass, gut fluorescence (GF), electron transfer system (ETS), and aminoacyl tRNA synthetase (AARS) activities, as indices of grazing, metabolism and growth, respectively. During March, a strong event of dust deposition was measured and an increase of zooplankton biomass was observed ten days later. However, chlorophyll did not increase at this weekly timescale. Indices of grazing, metabolism and growth increased almost three weeks later. Our preliminary results suggest that the so-called late winter bloom was taking place at the time of the dust deposition and this event seemed to reinforce the bloom, sustaining the increase in mesozooplankton biomass longer.

S8-7261

A global approach linking climate and marine copepod diversity to ecosystem functioning

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During the last decade, the relationship between biodiversity and ecosystem functioning has emerged as a vigorous new research area linking community and ecosystem ecology. This is partly due to concerns about the consequences of current climate change since changes in community composition can have a strong potential to alter ecosystem properties and the goods and services they provide. Community body size largely determines the types and strengths of flows of energy and materials in ecosystems thereby affecting ecological networks and the way ecosystems are structured and function. A recent study shows that climate-induced reorganisation of the North Atlantic planktonic ecosystem and shifts towards a smaller mean community body size of copepods may have negative effects on the drawdown of biological carbon and on fisheries by influencing the networks through which carbon flows. While the importance of the size structure of copepod communities for ecosystem functioning has been demonstrated at the regional scale, this phenomenon has not been investigated at a global scale. Such a study would yield a key insight to how climate-induced effects in the plankton may affect global carbon cycling providing important data for models of global climate change.

S8-7302

Ecological stoichiometry and trophic interactions: The role and fate of nutrients

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It is a well-accepted fact that nutrient limitation of plants affects the growth and survival of herbivores, generally leading to lower performance of herbivores feeding on nutrient stressed plants. The effect of plants' growing conditions on predatory organisms, feeding one trophic level up, has been much less studied, and there is a general consensus that such effects would be small as herbivores often show relatively strong homeostasis with respect to their nutrient content. Here, we challenge this view, and show from several examples that despite the fact that herbivores buffer much of the variance in nutrient stoichiometry of their food, effects of growing conditions of the primary producers can travel up the food chain. We discuss the implications of these findings, and make predictions on the consequences of these effects on food web interactions in a changing world.

S9 Posters

S9-6990

Studies on the species diversity of selective brachyuran larvae from the Red sea along Jeddah coastline

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Of the twenty-five brachyuran families reported from the Red sea, only forty three genera from eleven families are described. Brachyuran larval life cycle stages of the Jeddah seas are poorly studied in terms of morphological development. The area investigated in this study was confined to the central coast of Jeddah and included samples from five shoreline stations. All life cycle stages collected from field samples were subjected to morphological analysis and characterisation. Zoeae hatched from adult crabs were reared in the laboratory for subsequent stages for species identification. The most abundant crab larvae among the zooplankton were studied for the ecological factors that supported the abundance of the population. Morphological characterization of brachyuran larvae of the Jeddah coastline has implications for the study of systematic relationships and data derived on brachyuran larval community structure will help us better understand their role in estuarine trophic ecosystem dynamics.

S9-7016

What's on the menu? Feeding rates and selectivity of meroplankton (decapod) larvae in the Western English Channel

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Meroplanktonic larvae may be an important link in the coastal marine food web, providing food sources for fish larvae and other organisms. They are planktotrophic and are common in coastal zooplankton communities during the reproductive season. In order for meroplankton to survive, develop successfully and return to the benthos, it is important for them to obtain a good source of nutrition in the early stages of life. It is thought that the larvae ingest autotrophic and heterotrophic prey but little is known about their feeding preferences in coastal waters of the English Channel.

As part of the Western Channel Observatory time series programme, we determined the temporal distribution of meroplankton and ingestion rates of decapod larvae. We conducted feeding experiments from March-November to determine larval ingestion rates on natural mixed phytoplankton and microzooplankton assemblages. Complementary gut content analysis was performed using a polymerase chain reaction-based method for detecting prey DNA on specimens from both experimental and field samples.

Results suggest that the larvae feed on a range of food items from nanoeukaryotes through to the larger diatom chains and that they can be highly selective, as they do not always choose the most abundant prey species present.

Since these organisms show highly seasonal abundance peaks in many coastal systems, our results have important implications for understanding planktonic food web dynamics in mid-latitudes. The role of meroplanktonic larvae and their top-down control within pelagic food webs, investigated through classical feeding experiments and complementary molecular studies, will be discussed.

S9-7061

Trend and seasonality in larval supply: A 15-year time series analysis of meroplankton in a coastal upwelling area in Southwestern Atlantic Ocean

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Many marine benthic invertebrate species release thousands of larvae into the plankton during at least one annual reproductive pulse, which in turn should be able to get back to a benthic lifestyle. This benthic-pelagic coupling may increase available food for planktivores, resulting in bottom-up trophic effects in pelagic communities. This phenomenon has been monitored weekly over a 15 years off a coastal island in the Southwestern Atlantic Ocean (Cabo Frio Island, Brazil) to characterize periodicity in larval supply. As in temperate marine communities, reproductive pulses in the SAO are expected to be related to spring phytoplankton blooms, when food concentrations are high and larval survival enhanced. In Cabo Frio Island, seasonal pulses are less pronounced than inter-annual changes in meroplankton abundances and one to three intra-annual peaks became evident on time series data only when dominant groups (Cirripedia and Bivalvia) were removed. Abundance of non-dominant groups, including Decapoda and Echinodermata, exhibit a prominent seasonal pulse related to upwelling events. Larval supply for these groups increases considerably at the end of the austral summer (February-March) and also latter each four months (July and November). Inter-annual variance was particularly high in dominant groups due to a strong decrease in larval supply during the 1997-ENSO event, although a significant trend was not found in the total meroplankton abundance time-series. Significant ($p<0.05$) negative trend was only observed for ePolychaeta (-0.002 year^{-1}) and Ascidiacea (-0.003 year^{-1}) abundances.

S9-7104

Meroplankton assessment on the Abrolhos Bank, Brazil: Observations on major larval groups

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We studied the abundance and distribution of meroplanktonic larvae on the Abrolhos Bank ecosystem, the largest coral reef area in the South Atlantic, located on the eastern coast of Brazil between 16°40′ and 19°40′S. Sampling was carried out during July - August 2007. A total of 46 vertical plankton samples were taken at distances of 15 to 200km offshore, in local depths varying from 30 to 3370m that spanned coastal, shelf and slope waters. Sampling depth ranged from 15 to 200 m. Larval abundances were significantly higher on the bank (19 to 666 larvae m^{-3}) compared to slope areas (4 to 82 larvae m^{-3}). At the former, larvae of Bryozoa, Equinodermata, Gastropoda, Cirripedia, Polychaeta, Mollusca and Decapoda dominated, and their relative abundances varied within sampling stations. At slope stations, mollusk larvae accounted for 37% of the total abundance, summing up to 50% of the relative abundance in 14 of the 22 stations occupied at this area. Highest larval abundances occurred both at inshore stations and in the vicinity of coral formations situated on offshore bank areas, suggesting an important role of such reef structures in larval supply to the water column.

S9-7159

Distribution of decapod larvae off the Northwestern Iberia: Ontogenetic vertical migrations in the Portuguese upwelling ecosystem

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The distribution of decapod larvae is affected by a combination of biological and environmental variables. For example, behavioural responses to environment variables that control the vertical position of larvae can change during ontogeny and determine horizontal transport. In order to understand the ontogenetic vertical migration behaviour of decapod larvae of the western Iberia upwelling ecosystem, an oceanographic campaign was conducted in May 2002. A fixed station approximately 21km off the Iberian coast was sampled every 2 hours for 69h with a Neuston net at the surface and a Longhurst Hardy Plankton Recorder (Pro-LHPR) throughout the water column. Temperature and salinity were registered hourly. The vertical migration behaviour of nine of the most abundant taxa sampled, including *Processa nouveli, Pandalina brevirostris, Philocheras bispinosus, Anapagurus* spp., *Pagurus bernhardus, Pisidia longicornis, Atelecyclus rotundatus, Liocarcinus* spp. and *Necora puber*, were analysed by stage in relation to the diel cycle, salinity and temperature. The weighted mean depth of the studied taxa varied during ontogeny, with early zoeal stages distributed closer to the surface and older stages located gradually deeper in the water column. Except for *N. puber*, temperature never explained the distribution of newly hatched larvae. The first and the last zoeal stages of *P. nouveli*, *Anapagurus* spp. and *A. rotundatus* showed opposite responses to salinity suggesting an ontogenetic shift to this environmental predictor. The newly hatched larvae of *Anapagurus* spp., *P. longicornis, A. rotundatus* and *Liocarcinus* spp. seem to be transported in the less saline superficial water lens advected from the coast.

S9-7239

Phenology and dispersion patterns of decapod larvae in the Cantabrian Sea during 2006

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Decapod larvae constitute an important fraction of the meroplanktonic community in European coastal waters. Their abundance and distribution are ruled by environmental variables such as temperature and phytoplankton concentration, but also by adult reproductive phenologies. In the Bay of Biscay, the knowledge on the ecology of these organisms is limited to a few studies focused on the biology of adults while information on their larval phase is scarce. During a 12 month study, as part of the RADIALES project, we identified and staged decapod larvae sampled from a three-station transect oriented perpendicularly off Gijón (N Spain). These data provide insights on the reproductive phenology of sampled decapod species, larval releasing zones (coastal vs. oceanic), larval dispersal patterns (offshore vs. inshore) and their interaction with physical variables.

S9-7267

Mesoscale beta diversity and spatial nestedness of crustacean larvae in the coastal zone off central-southern Chile

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Spatial connectivity among populations is a central theme in marine ecology. This study evaluates the presence of spatial diversity patterns in meroplanktonic stages of decapods and stomatopods. We hypothesize that the β diversity of these groups increases with increasing geographic distance at the mesoscale, which is related to the spatial nestedness of larval richness at the local scale. Seven oceanographic cruises were conducted between May 2006 and February 2008, ranging from Cobquecura (36°7'S) to Coliumo Bay (36°32'S). Sampling was carried out using a Bongo net (300 µm) towed obliquely to 15-m depth. To test the hypothesis we: (i) quantified the β diversity of early stage decapods and stomatopods, (ii) adjusted a linear model between β diversity and the geographic distance between all possible pairs of sampling sites, and (iii) carried out nestedness analysis of species richness to evaluate the effect of local transport on species diversity. We found a positive relationship between β diversity and geographic distance, and observed a nested pattern in the majority of analyses. This suggests that biophysical coupling (*i.e.* the relationship between advective larval transport and behavior) plays a crucial role in the spatial structure of diversity at this geographic scale, where a source-sink dynamic predominates between nearby sites. The observed relationships indicate limited larval dispersal, which would induce low levels of population connectivity. These factors could have important consequences on the differentiation of benthic communities at relatively small spatial scales.

General Poster Session

GP-6879

Comparative studies on the performance and survival rate of fish larvae fed *Artemia* vs. cultured freshwater zooplankton

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Achieving great success in fish farming operations depends on the availability of a ready supply of fish larvae. The successful rearing of these larvae is in turn dependent on the type, quality, and quantity of feed available to these larvae. The larval stage has therefore been a major bottleneck in fish farming production, since live food is difficult to provide and formulated feeds often do not meet larval nutrient requirements and usually result in poor larval growth and survival. Although *Artemia* has been a major (and often only) live food source for larval fish rearing, the expansion of aquaculture production and subsequent increased demand for *Artemia* cysts soon exceeded the supply and prices rose exponentially. The need to find an alternative to *Artemia* as a larval food source was therefore imperative to successful fish farming. This study examined the growth performance and survival of fish larvae fed *Artemia* vs. those fed with freshwater zooplankton cultured in semi-enclosed ponds fertilized with dry poultry droppings of 5% nitrogen concentration. The harvested freshwater zooplankton and *Artemia* were fed to fish larvae from 3 days of hatching onward. Study results revealed marked significant differences ($P < 0.05$) in survival rate, mean weight gain, and length changes of the larvae. Fish larvae fed the cultured freshwater zooplankton had higher survival rates (81.64%), mean weight gains (14.0 g), and length changes (3.20 cm) compared to the *Artemia* fed larvae (65.31%, 6.0 g, and 66 cm respectively).

GP-6984

Digesting the errors associated with gut-content analysis in gelatinous zooplankton: An intercomparison of digestion time methods and recommendations

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Blooms of gelatinous zooplankton can cause economic damage to various industries, and have been linked to changes in ecosystem structure, in part due to their trophic impact and high feeding rates. Gut-content analysis is often used to describe natural feeding preferences. Selectivity and feeding rates are determined by combining gut-content counts with estimates of the digestion time of the prey items. If we are to obtain accurate feeding rate estimates from gut-content analysis, we need to apply accurate estimates of predator- and prey-specific digestion times. An examination of the literature reveals that a variety of different methods have been used to estimate digestion time, with wide-ranging time intervals of observation (from continual observation to >1 hour intervals), and different definitions of the start and end-point criteria. We examine how these different methods produce different digestion times using both models and a synthesis of real data. We test our predictions of the differences between methods through experiments with the scyphomedusa *Aurelia aurita*. This highlights how the application of different methods to measure digestion times can produce radically different results. Finally, we discuss the errors with each method, and suggest the best-practice for experimentally determining digestion time.

GP-7084

UVR effects on nauplii from South Atlantic coastal waters (Patagonia, Argentina): Does food with high concentrations of UV-absorbing compounds make a difference?

Rodrigo J. **Gonçalves**[1,2], Mariela L. Spinelli[2,3], Rodrigo D. Hernández Moresino[1,2], Virginia E. Villafañe[1,2], Fabiana L. Capitanio[2,3] and E. Walter Helbling[1,2]
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Zooplankton larvae are commonly considered to be sensitive to ultraviolet radiation (UVR, 280-400 nm), which may cause mortality, impaired locomotion, and impaired feeding. Zooplankton may obtain protection via bioaccumulation of UV-absorbing compounds from their prey. In order to test the importance of bioaccumulation of UV-absorbing compounds in protecting copepods against UVR, nauplii were collected in surface waters and fed, at *in situ* temperature for 24 hours, under one of four different food treatments: a) cells < 20 µm from natural phytoplankton; b) cultures of *Chaetoceros* sp., c) cultures of *Prorocentrum micans*, and d) a control of filtered water (0.22 µm). After feeding, the nauplii were exposed to UVR and PAR (400-700 nm) for 4 hours (irradiances of 0.7, 48 and 164 W m^{-2} for UVB, UVA and PAR, respectively), using two radiation treatments (UVR+PAR and PAR). Motility and behavior were recorded continuously before, during, and after exposure. The concentration of UVR-absorbing compounds (estimated spectrophotometrically) had higher values in larvae fed with natural phytoplankton (cells < 20 µm) and with *P. micans* than in the other two treatments. There were no significant effects of UVR on mortality or swimming speed in any of the four food treatments, but UVR-exposed nauplii showed less activity near the surface than those exposed only to PAR. In the field, short term exposure (*i.e.*, 24 hours) to algae rich in UV-absorbing compounds may not be enough for nauplii to bioaccumulate significant amounts of these substances, and thus they might rely on other alternatives such as swimming to deeper waters.

GP-7107

Data management in support of zooplankton research

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Marine zooplankton ecological and biogeochemical research is conducted using a wide variety of sampling, experimental, and modeling systems. The diversity of data types and the data volume produced by researchers is growing exponentially. The interdisciplinary nature of oceanographic research requires that many different data sets be aggregated, integrated, analyzed, and shared to yield a comprehensive scientific understanding of complex ocean processes. To facilitate this process, in 2006, the US National Science Foundation funded the Biological and Chemical Oceanography Data Management Office (BCO-DMO) to serve the data management requirements of investigators funded by the NSF's Biological and Chemical Oceanography Sections. BCO-DMO staff members collaborate with investigators to promote better data management practices throughout the research program and manage the resultant marine biogeochemical, ecological, and oceanographic data and information developed in the course of scientific research. The BCO-DMO ensures the data are documented, stored, disseminated, and protected long after the research is completed. An important goal is to facilitate regional, national, and international data exchange through improved data discovery, access, display, download, and interoperability. Highlighting the available zooplankton and related biogeochemical data, we describe the capabilities of the BCO-DMO data system: geospatial and text-based data discovery and access systems; recent enhancements to data search tools; data export and download utilities; and strategic use of controlled vocabularies to facilitate data integration and improve interoperability.

GP-7144

Zooplankton diversity in freshwater lakes with relation to trophic status, Shimoga district, Karnataka, South India

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Our present work focused on the taxonomic composition of zooplankton in three freshwater lakes of the Shimoga district (Karnataka, South India) from October 2009 to September 2010. During the study period, a total of 39 zooplankton species (belonging to groups Rotifera, Cladocera, Copepoda, and Ostracoda) were identified across the three lakes. Highest diversity was found in Gobbur Lake (27 species present), followed by Bosga Lake (23 species present) and Sogane Lake (20 species present). The group Rotifera was most prevalent in all three lakes, representing 45-50% of the total species captured. Diversity and density changes in the lakes were studied using diversity indices. Comparison with results from earlier investigations (1986-1987) indicated that significant changes have occurred in the lakes. Study results also clearly indicate intensified eutrophication in each of the lakes.

GP-7146

Enhanced capture of krill using an LED based strobe light on a 1-m2 MOCNESS

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Adult krill are well known for their ability to avoid capture by standard oceanographic plankton nets. Previous studies have shown enhanced catching rates when the nets were equipped with flashing lights. During a study of krill/herring interactions in Franklin Basin (Gulf of Maine), MOCNESS tows were made to provide ground truth for acoustic surveying of the krill and fish. The 1-m2 MOCNESS was equipped with a newly designed LED based strobe light and a study was done to evaluate its efficacy in increasing krill capture rate. Two horizontal tows were done in the study site, which was a region with high numbers and biomass of adult krill (mostly *Meganyctiphanes norvegica)*. Each tow consisted of a sequential series of down and up casts through a set depth interval (*e.g.*, 60 to 75 m at night; 160 to 190 m during daylight). The strobe light was set to either "on" or 'off' with four of the eight nets (335 µm mesh) sampled with the strobe flashing and four sampled with the strobe off, in a random sequence. Total displacement volume was significantly increased when the strobe light was on due largely to the enhanced catch of adult krill. These results suggest that the new MOCNESS strobe light system significantly reduces the effects of krill net avoidance and reaffirms the results of earlier studies. Studies of krill distribution that use standard nets without a strobe light system risk seriously under estimating the krill standing stock in the study region.

GP-7157

A place for *Mnemiopsis*: Spatio-temporal habitat characterization in Scandinavian waters

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In 2005 the ctenophore *Mnemiopsis leidyi* was first observed in Scandinavian waters, and a year later it had spread all the way into the central Baltic. Originating from the American east coast, *Mnemiopsis* is known for its very wide tolerance to different environmental conditions. We have examined how the physical and biological environment in the Baltic shapes the abundance and distribution of *Mnemiopsis* in this newly invaded region. We conducted monthly field sampling throughout a year around the west coast of Sweden and into the central Baltic. Being the dominant gelatinous plankton along the Swedish west coast, *Mnemiopsis* was present from July to February with peak abundances of 5 ind. m^{-3} in October. October was also the month with the widest geographical distribution when *Mnemiopsis* extended into the central Baltic. Still, the occurrence of *Mnemiopsis* in the Baltic was geographically and temporally very limited, instead the native *Aurelia aurita* dominated among the gelatinous plankton. Our data suggests that *Mnemiopsis* is well established in Skagerrak and Kattegatt, while its sporadic appearance in the Baltic is associated with advection and seem to be limited partly by interspecific competition with *Aurelia aurita*.

GP-7184

Molecular and morphological phylogeny of Paracalanidae, Giesbrecht 1892 (Copepoda: Calanoida)

Astrid **Cornils**[1], Leocadio Blanco-Bercial[2], Sigrid B. Schnack-Schiel[1] and Ann Bucklin[2]
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The Paracalanidae (Giesbrecht, 1892) is a family of marine epipelagic calanoid copepods with a worldwide distribution from temperate to tropical waters. Species of this family can be very abundant in coastal, shelf, and oceanic regions. Currently, the family includes a total of 83 species in seven genera: *Acrocalanus, Bestiolina, Calocalanus, Delibus, Mecynocera, Paracalanus* and *Parvocalanus*. The genus *Mecynocera* has only recently been included in this family and its separation from other genera has been questioned. Despite the ecological importance of the group in the many marine regions, little is known about phylogenetic relationships within the Paracalanidae. The aim of the current investigation is to examine the molecular and morphological phylogenetic relationships among the genera of this family. DNA sequences were determined for 21 species of all 7 genera for both mitochondrial and nuclear genes; multigene phylogenetic analysis was carried out based on more than 2500 base-pairs; and a set of morphological traits was characterized for the same species. Molecular and morphological phylogenetic analyses were done both separately and in combination. The analysis resolved relationships among the genera of the Paracalanidae and provided a clearer view of the evolution of this ecological important and evolutionarily successful calanoid family.

GP-7200

Chromosome studies on the marine harpacticoid copepod *Euterpina acutifrons* (Dana, 1848)

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Cryptic and sibling species both refer to taxa that are difficult to distinguish morphologically and these species are common in marine habitats. Recent studies have shown that existence of cryptic and sibling species in copepods, one of the most diverse organisms in the world. Cytogenetic investigations have been used as a tool to understand the evolutional histories and to help in the discovery of cryptic and sibling taxa in marine invertebrates. Parameters such as chromosome morphology and dimensions are often species-specific, and therefore also potentially useful in phylogenetic reconstruction. In our study, chromosome morphology of *Euterpina acutifrons*, a widely distributed and commercially important species in fish aquaculture, has been described. Cell suspension method was used to obtain the metaphase chromosomes which were also tested with conventional karyotyping and argyrophilic nucleolar organizer region (Ag-NOR) staining. From the results, embryos were proven to be a suitable source of cells to obtain the greatest number of metaphase spreads. Counts of 100 Giemsa-stained metaphase plates gave a diploid number of 2n = 20. The karyotype consisted of 1 pair of metacentric, 7 pairs of submetacentric, and 2 pairs of telocentric chromosomes. Ag-NOR staining was ineffective in enhancing nucleolar organizer regions on chromosomes of *E. acutifrons*. Further investigations using C-banding, restriction endonuclease enzyme banding, or fluorescence *in situ* hybridization (FISH), which have been successfully applied on fish and bivalve cytogenetic studies, should be introduced to copepods chromosome studies.

GP-7205

Assessing the relative risk of inter- *vs.* intra- coastal ballast water transport of non-indigenous zooplankton

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Ballast water represents the primary vector for the transfer and introduction of non-indigenous zooplankton. All vessels intending to discharge overseas ballast water in Canadian ports are required to conduct mid-ocean exchange in order to minimize this risk. However, intracoastal vessels arriving from nearby ports may be exempt from exchange because they share common waters, whereas those from further away are required to exchange. We sampled zooplankton in the ballast water of transoceanic exchanged (TOE), intracoastal exchanged (ICE), and intracoastal unexchanged (ICU) vessels on Canada's west coast (WC), east coast (EC), and Great Lakes Basin (GLB) to assess the relative risk associated with these three vessel classes. We compared indigenous and non-indigenous zooplankton (NIZ) density, propagule pressure, taxonomic richness, and community composition among TOE, ICE, and ICU vessels. The WC and GLB received greater densities of NIZ than the EC, and the WC had the highest NIZ propagule pressure of the three regions. On the west coast, NIZ propagule pressure and density was significantly higher in unexchanged (ICU) vessels. On the east coast and Great Lakes, TOE ships had the highest NIZ propagule pressure and densities. Unexpectedly, ICU vessels transporting common waters to Vancouver ports represented the greatest invasion risk to Canadian waters, largely because these vessels (i) came directly from previously invaded ports, facilitating secondary introductions, (ii) had shorter journeys that favour survivorship of organisms, and (iii) transported NIZ past natural dispersal barriers. Modifications to current ballast water management strategies of intracoastal vessels could mitigate this risk.

GP-7214

Barnacle larvae production on Southampton Water, England

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In the past half century, a number of studies have described the general composition of the mesozooplankton of Southampton Water, highlighting aspects about major components and identifying calanoid copepods and barnacle larvae as the major elements. In order to expand the knowledge on the contribution of barnacle larvae to the pelagic community, 108 quantitative zooplankton samples were collected during a period of 19 months from three fixed stations along the estuary. The overall zooplankton community was mainly composed of holoplanktonic forms (~69%), followed by meroplanktonic forms (~30%) and tychoplanktonic forms (~1%). Barnacle larvae averaged 53% of the meroplanktonic forms and presented similar composition and seasonality reported in previous studies, with *Austrominius modestus* dominating the barnacle fraction throughout the year but outnumbered by *Balanus crenatus* from February to May. Of the eight remaining barnacle species found only *Amphibalanus improvisus*, *Semibalanus balanoides* and *Verruca stroemia* were present in substantial numbers to allow production calculations. Total barnacle larvae production was 33.12 mg C m^{-3} yr^{-1} (or 0.09 mg C m^{-3} d^{-1}) on average for the three stations with *A. modestus* accounting for 55.3% of that production value, followed by *B. crenatus* (34.3%), *A.improvisus* (6.9%), *S. balanoides* (3.0%) and *V. stroemia* (0.5%).

GP-7231

COPEPOD: A global plankton database with data and DATA

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The Coastal & Oceanic Plankton Ecology, Production, & Observation Database (COPEPOD) is an online database of plankton abundance, biomass, and composition data compiled from a global assortment of cruises, projects, and institutes. COPEPOD's online zooplankton and phytoplankton data content ranges from longer term ecosystem monitoring surveys to detailed process studies, each accessible via a variety of searchable indices and detailed visual and text-based content summaries. In addition to these hundreds of individual data sets, COPEPOD offers a variety of pre-generated compilations and gridded field products designed to assist in basin and global scale studies and modeling. One of the biggest challenges in working with plankton data is finding data whose methodology and content are immediately applicable to the user's research questions. Once found, the next challenge is acquiring these data in a format that is immediately usable by the researcher and/or their computer software. Using the new plankton DATA (Discovery, Access, Tabulation, & Application) interface, the user can easily customize and execute a detailed search in which the results quickly illustrate exactly what data are available for the plankton groups, mesh parameters, and geographic region that user selected. The DATA system then offers a variety of raw and enhanced-content output options and data formats that allow the user to tailor the data to their research and/or software needs.

GP-7243

Copepod distribution in a pair of mesoscale eddies off Concepción, central-southern Chile

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The generation of mesoscale eddies in the coastal band is a frequent process in the region off central-southern Chile and these structures might contribute to a transport of plankton towards the offshore. Previously, we have shown that eddies greatly expand the offshore distribution of some typically coastal species of copepods in this upwelling region. Here, the composition and distribution of copepod species in relation to a pair of eddies closer to the coastal band were analysed using zooplankton integrated (0-200 m or the maximum depth if less) samples, collected at 33 stations during the summer (January 2009), together with hydrographic profiles and satellite information. A cluster analysis showed differences in the species composition between both eddies; the cyclonic eddy concentrated mainly oceanic species whereas the anticyclonic eddy included a mixture of oceanic and coastal species. This difference appears to be linked with the age of the eddies and their chlorophyll *a* concentration, with the anticyclonic eddy being younger and containing higher concentrations). A comparison of the abundance of coastal species in the eddies and outside of them in the coastal band showed a significant difference only in the case of *Aetideus armatus*, being highly concentrated in anticyclonic eddies. Some of the dominant coastal species, including *Acartia tonsa*, *Oithona similis*, and *Drepanopus forcipatus,* had between 17% and 39% of the total abundance in the samples represented in the pair of eddies. This suggests that an important fraction of the population is potentially exported to the coastal transition zone by mesoscale eddies in this region.

GP-7260

Zooplankton community response to multiple anthropogenic stressors

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In most estuaries and harbours numerous stressors related to ocean- and land-based anthropogenic activities co-occur. These different stressors may interact and expected community responses cannot necessarily be derived from studies addressing one factor at a time. Three frequent stressors in marine coastal areas are eutrophication, oil, and contaminant inputs, where oil for example may modulate partitioning and either increase or decrease bioavailability of contaminants. Likewise, increased nutrient loads and extra nutrients might have a dilution effect on toxic compounds. We aimed at assessing the combined and solitary effects of contaminants, oil, and eutrophication on natural marine zooplankton communities and performed pelagic microcosm (100 L) and mesocosm (2.5 m^3) experiments. Our model contaminant was emamectin benzoate (EMA). It is an aquaculture pharmaceutical and has a selective toxicity to different zooplankton species. The applied oil was pure mineral oil, intended to separating the effect from oil itself from the effect of oil as a mixture of several more or less toxic compounds. The different zooplankton groups varied in their response to the different stressors. Crustaceans were generally negatively affected by EMA. Effects of pure oil were less prominent, for instance cladocerans seemed to be negatively affected while mollusc and polychaete larvae apparently showed no response neither to EMA nor oil. Gelatinous groups were too scarce in the experiments for determination of their response to the treatments.

GP-7262

Predation and diel behavioral patterns in a Chaetognath

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Experimentally determined feeding rates of chaetognaths are few. We experimentally quantified feeding rates of the chaetognath *Sagitta setosa* on co-occurring copepods of varying states and species and thus with different behaviors and presumed different detectability by the chaetognath predator. Feeding rates were highly variable, but mean predation rates on various prey were generally higher than published rates inferred from gut content analyses of field caught animals. Feeding rates appeared to depend on prey specific differences related to behavior, as well as on predator and prey size. In some cases, larger prey were killed but not ingested. Preliminary results from video observations suggest that *Sagitta* changes its predation strategy between day and night time.

GP-7264

Winter distribution of *Mnemiopsis leidyi* (Agassiz, 1865) in the southern North Sea and first record in French waters

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We report the first observation of the invasive ctenophore *Mnemiopsis leidyi* on the French coast of the Dover Strait. The maximum abundance observed was 61 ind. m^{-3} in September 2009. We also investigate the distribution of ctenophora species overwintering in the southern North Sea in 2009 and 2010, with a sampling effort extending from the eastern English Channel to latitudes up to 56°N. Recurrent patches of *M. leidyi* (max. 0.3 ind. m^{-3}) were observed off The Netherlands and the Danish coasts and were composed of large individuals (from 1 to 4 cm). The occurrence of the carnivorous *M. leidyi* in the southern North Sea and the Dover Strait may have negative impact on spawning and nursery habitats of plaice (*Pleuronectes platessa*) and sole (*Solea solea*), two important commercial species in the North Sea. It is therefore essential to closely monitor the effects of *M. leidyi* on the zooplankton community (including ichthyoplankton).

GP-7274

Dormancy in *Calanus pacificus californicus*: Are copepods safe from predators while overwintering?

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Calanus pacificus californicus, the dominant copepod in the California Current System, shows a biphasic life history during winter in the Southern California region. While some of the population enters dormancy, a smaller portion remains active, presumably to take advantage of the episodic blooms that occur in the Southern California Bight (SCB). An additional potential advantage of dormancy is a reduction in surface predation mortality, since dormancy occurs at depths greater than 450 m. However, previous work suggests that potential predators may also dwell near the deep dormant layers of *C. p. californicus* in the SCB. Yet the predator-prey interactions between dormant *C. p. californicus* and its mesopelagic vertebrate and invertebrate predators have not been quantified. In order to characterize such predator-prey interactions this work combines different sampling techniques. MOCNESS zooplankton tows and acoustic and optic surveys using the novel package ZOOPS-O (ZOOPlankton Sonar and Optics system) were carried out in the Santa Barbara Basin from 25 September through 3 October 2010 as part of the research cruise Cal-Echoes on board the R/V *Melville*. The dormant state of CV copepods was confirmed by gut pigment assays. Vertical distributions of *C. p. californicus* and potential predators were obtained from net tows and optical and acoustical data. Predation will be evaluated by the presence of *C. p. californicus* body parts in the gut contents of fishes and diverse zooplankton. This research will provide further knowledge on the predator-prey interactions that may affect the dormant population of *C. p. californicus* in the SCB.

GP-7281

Secundary production of Acartia (Copepoda: Calanoida) in Patos Lagoon Estuary

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The Patos Lagoon (~10.227 Km^2), located in the southeastern portion of Brazil, is the world's largest choked lagoon with ~10% of the southern portion being characterized as a coastal plain estuary. With the objective to evaluate the secondary production of zooplanktonic organisms in the Patos Lagoon estuary, a continuous monitoring program was implemented in April 2009 by the zooplankton laboratory of the Federal University of Rio Grande (FURG). In this program, zooplankton samples were collected on a monthly basis from two fixed locations within the estuary with mini-Bongo nets of 30 cm diameter and 200 and 90 µm mesh nets equipped with calibrated flowmeters. During the period of April 2009 to April 2010, a total of 33 quantitative samples were analysed. Copepods represented 40% of the organisms collected with the 90 µm mesh, with adults and copepodites of *Acartia tonsa* accounting for ~19% of the total copepods found at both locations. Daily production rates of *Acartia tonsa* averaged 0.36 mg C m^{-3} d^{-1} at the Yacht Club station and 3.31 mg C m^{-3} d^{-1} at the Prainha station. The annual value of 1206 mg C m^{-3} yr^{-1}, recorded at the Prainha station, approaches the highest literature values for *Acartia* found in other estuaries, indicating that this estuary has high copepod productivity.

GP-7291

Industry ADCPs reflect the responses of zooplankton and micronekton to the Deepwater Horizon oil spill in the Gulf of Mexico

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The *Deepwater Horizon* (MC252) oil spill resulted in an unprecedented discharge of oil into the Gulf of Mexico. The uncontrolled release of crude oil into a pelagic ecosystem from such a deep-sea source has the potential to impact a wide range of biological communities. Many mesopelagic taxa undertake diel vertical migrations into the epipelagic depths near sunset, forage in the surface waters during darkness, and return to the depths before sunrise. The presence of oil in the waters that are occupied either constantly or transiently by zooplankton and micronekton could produce either acute toxicity or sublethal responses manifested by changes in the timing or vertical amplitude of migrations. ADCP current meters mounted on four BP deepwater exploration and production vessels were used to quantify how vertical migration patterns changed over a period spanning the spill (Apr 1 – Sep 11, 2010). The results indicate that acoustic backscattering declined in the upper 200 m at two sites immediately near the spill while a control site located 60 nautical miles from the spill remained generally constant. The timing of arrival and departure from the surface was also more variable during the spill. These data suggest that the MC252 spill had an impact on the behavior and potentially the abundance of pelagic and mesopelagic zooplankton and micronekton, which extended beyond the time at which the well was capped.

GP-7294

Microzooplankton dynamics in the Bahía Blanca Estuary, Argentina

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Microzooplankton (MZ) has a key role in the energy transfer from the primary producers to larger zooplankton. The aim of this study was to analyze the variation of MZ in spring-summer during two years, 2006-2008, in relation to environmental variables and phytoplankton abundance. Sampling was carried out at six stations along the Bahía Blanca Estuary, numbered from 1 (inner) to 6 (outer). Samples were taken with a Van Dorn bottle and fixed with Lugol's solution. Enumeration of organisms was done with an inverted microscope, following the Utermhöhl´s technique, and biomass was calculated using the morphometric method. The MZ assemblages were composed of tintinnids, aloricate ciliates, heterotrophic dinoflagellates, rotifers, and copepod nauplii. MZ biomass ranged from 5.0 to 16.2 µg C l^{-1}. Numerical abundance was significantly higher during the 2006/2007 period at stations 4-6. For both studied periods a positive correlation of MZ abundance with temperature, salinity and pH was found. Also, a negative correlation was observed with turbidity and particulate organic matter (POM). MZ carbon was positively correlated with salinity and pH, but no correlations were found with phytoplankton carbon or chlorophyll *a*. Using the Bray & Curtis similarity index based on microzooplankton abundance, we found that stations were associated into three groups: internal (1-2), intermediate (3-4) and external (5-6). Temperature, salinity, pH, turbidity, and POM were the principal factors forcing the temporal dynamics of the MZ in the Bahía Blanca Estuary.

GP-7301

Distribution of the copepods *Calanus chilensis* and *Calanus australis* in the coastal band, coastal transition zone, and oceanic waters off central-southern Chile

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The distribution of *Calanus* in the coastal band of the eastern South Pacific Ocean has been a matter of controversy since two species, *C. chilensis* and *C. australis*, have been cited but not all the authors agree that they both coexist in this region. These species are morphologically similar and the attributed differences are only distinguishable in the late stages. In the coastal area off Concepción, both species have been reported in some cases but more recent publications refer only to *C. chilensis* as the typical representative. Almost no information is available on the distribution of *Calanus* in the coastal transition zone (CTZ) and oceanic waters in this region and, in general, in the open waters of the eastern South Pacific. In this study, 35 zooplankton samples (0-100 m) were collected during cruises of opportunity which covered the CTZ and adjacent oceanic waters (34-38°S, 74-84°W) during the spring (November 2006). A high proportion of early developmental stages (63%) in the samples could not be identified but adults stages of both species were present in the CTZ and oceanic waters. *C. australis* abundance showed a trend of decrease towards the northern section while both species displayed similar abundances in the CTZ and oceanic areas of the southern section. In the coastal band, *C. chilensis* was not a dominant component at the time of sampling (relative abundance <1%). This suggests that the area off Concepción might represent a northern limit to the distribution of *C. australis* where it also coexists with *C. chilensis.*

GP-7313

Advances in biophysical modeling of *Euphausia mucronata* in the Southeast Pacific

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Euphausia mucronata is an endemic species of the Humboldt Current System (HCS), which dominates the coastal zooplankton constituting more than 90% of the euphausiid biomass (15 - 42 mg C m^{-3}) of the highly productive coastal upwelling region off central Chile. This species is an active daily vertical migrant, playing an important role in carbon transfer toward the upper trophic levels, and constituting the main prey for the most important Chilean pelagic and demersal resources. The objective of this study is understand the mechanisms that allow *E. mucronata* to be a dominant species in the strongly dynamic coastal upwelling off central Chile based on modeling biophysical tools. We used a validated 3D hydrodynamic model (ROMS) of the Southeast Pacific region, with 10 km spatial horizontal resolution and 30 vertical layers with a high resolution over the first 100 meters, coupled to an individual-based model (IBM) of the lifecycle of *E. mucronata*. The hydrodynamic model resolved well the mesoscale oceanographic features of the region. The IBM configuration simulated the buoyancy of eggs and swimming ability (velocity and migrational ranges) of larvae and adults based on observational/experimental data. In addition, temperature-dependent growth was used to simulate developmental stages based on molting rates of *E. mucronata*. Modeled initial conditions, distributional patterns, *E. mucronata* abundance/biomass, and egg production were based on pooled data from two years of cruises (674 plankton samples). Mortality rates were obtained from experimental data on *Euphausia Pacifica*. This research is a first attempt to model this HCS key species using a biophysical approach.

GP-7325

Sapphirinid copepods as predators of doliolids: Their contribution to doliolids mortality and sinking flux

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The sapphirinid copepods are distributed widely in the epipelagic zone of tropical and subtropical waters of the world oceans. The male individuals are known to show beautiful iridescence, which is closely related with mate-finding mechanisms. Some sapphirinids are also known to be associated with salps as parasites and predators, however studies about the feeding ecology are extremely limited so far. In the present study we investigated predation behavior of sapphirinid copepods on doliolids, small barrel-shaped pelagic tunicates, to determine (1) if doliolids are utilized as a primary food source by sapphirinids and (2) if sapphrinids contribute significantly to doliolid mortality. We observed that *S. nigromaculata*, *S. opalina*, and *S. darwini* voraciously prey upon *Dolioletta gegenbauri* through on board observation. On average, 60-70% of the doliolid body was consumed by two adult females within a 24 hour period. Predation rate was estimated as 17-24 ug C $copepod^{-1}$ d^{-1}, corresponding to 100-140% of the body carbon of the copepod. Attachments of sapphirinids on doliolids were also confirmed in the field using a Video Plankton Recorder. Attacked doliolids, determined via trace evidence (*e.g.,* an open wound) were collected without sapphirinids using a particle interceptor trap (PIT) moored at 150 m depth, indicating that discarded doliolids contribute to particulate sinking flux. This study revealed that sapphirinid copepods play a significant role in epipelagic zone of warm water ecosystems as a predator of doliolids and a producer of large-sized sinking particles.

GP-7357

Analysis of zooplankton time series from an upward looking sonar: The data-cube concept

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Long time series of acoustic sounding data present the opportunity to examine the timing, vertical distribution and behaviour of zooplankton and other organisms. In this poster, we examine data from a small, inexpensive, single frequency (200 kHz), upward-looking water column profiler that is mounted as part of the VENUS cabled observatory in Saanich Inlet, British Columbia, Canada, and introduce the concept of depth-time 'cubes' for thinking of long time series of acoustic data. A two-year long time series of continuous scattering measurements is presented to illustrate seasonal changes throughout the entire water column at this location. Even using very simple algorithms and uncalibrated data at a single frequency, we can closely monitor seasonal changes in the timing of zooplankton diel vertical migration with high temporal resolution. As expected, the diel vertical migration is shown to relate very closely to sun declination, but the simple algorithm used to find the timing in this preliminary study was often confused by fish and physical water movements. A more intelligent algorithm taking advantage of the high temporal resolution of the data is required. Examples of interesting behaviour and fish/zooplankton interactions in this very rich dataset will be highlighted.

GP-7549

Spring size spectra and production of net zooplankton in Laizhou Bay, Bohai Sea

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Laizhou Bay is an important fish spawning ground in the Bohai Sea, China. Based on the zooplankton compositions in the Laizhou Bay, Bohai Sea in May and June, 2008, the net zooplankton size spectra, biomass and production rate of were analyzed. Results showed that zooplankton normalized biomass size spectra fitted closely with a linear regression line (slope=-0.96(May), -0.90(June), intercept =14.63(May), 12.85(June)). In the two months zooplankton compositions were similar, and *Acartia bifilosa*, *Calanus sinicus* and *Sagitta crassa* are the main species contributors to the high biomass size classes -1~1, 5~7 and 7~8 (Log2 individual carbon content), respectively. Zooplankton abundance, biomass and production rate showed remarkably inter-seasonal variations with a mean of 3.1×10^5 ind. m^{-3}, 24.6mg m^{-3} and 5.04 mg C $m^{-3}day^{-1}$ in May, and 3.9×10^3 ind. m^{-3}, 9.7mg m^{-3} and 1.65 mg C $m^{-3}day^{-1}$ in June respectively. We estimated roughly the potential sustainable resource of zooplankton less than 10% requirement of the nekton organisms standing stock, especial some fishes in the Laizhou Bay.

W1 Poster

W1-7210

Retention of *Engraulis ringens* eggs and larvae, connectivity among spawning and recruitment zones, and their relationship with invertebrate predators and larval food distributions in the southern part of the Humboldt Current

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We utilized an IBM for the early life stages of *Engraulis ringens*, coupled with an hydrodynamic model (ROMS) to assess retention and connectivity among spawning zones, and their relationship with invertebrate predator and larval food rich areas distribution along the coast of central Chile. Initial conditions of ichthyoplankton (abundance, distribution) for the IBM and of zooplankton data were obtained from egg surveys done during the 2005 spawning season. IBM outputs for the icthyoplankton were evaluated through GAMs, zooplankton distribution was analyzed with geostatistics, and ANOVAs were utilized to compare both. Results show that retention was stronger in three zones (Lebú-Corral, Golfo de Arauco, and Constitución). Connectivity was observed in the south-to-north direction, particularly between Lebu-Corral towards Golfo Arauco and also towards the Pre-recruitment zone. At the spawning zones, while the abundance of copepods (larval food) was high, the abundance of gelatinous (chaetognaths, medusae, siphonophores and ctenophores) and crustacean predators (euphausiids and larval decapods) were low. The highest abundances of gelatinous predators were uncoupled with the highest abundances of *E. ringens* eggs and larvae. We conclude that the different spawning zones along central Chile show diverse levels of egg and larval retention and of connectivity with the recruitment zone, and that the spawning zones are safe sites for eggs and larvae in terms of food availability and invertebrate predator abundance.

W2 Posters

W2-6968

Molecular systematics and biogeography of *Oithona* spp. of the Atlantic Ocean

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The family *Oithonidae* Dana, 1853 (Copepoda, Cyclopoida) is one of the most abundant groups in the pelagic realm throughout the world's oceans. Although knowledge has increased about the life history and ecology of *Oithona* spp. in recent years, few studies to date have used molecular genetic approaches. This study analysed rDNA sequence variation of a portion of the large subunit (28S) ribosomal rRNA gene for individuals of three *Oithona* species: *O. nana, O. helgolandica* (*sensu* Ramirez, 1969) and *O. atlantica* in samples collected from selected regions of the North and South Atlantic Ocean. The 28S rRNA gene tree and pairwise distance matrix clearly resolved *Oithona* species and confirmed the presence of three distinct species in the sampled regions. Analysis of geographic variation of 28S rRNA haplotype frequencies of *O. helgolandica* (*sensu* Ramirez, 1969) revealed evidence of genetic differentiation among populations in three regions: western and eastern North Atlantic and western South Atlantic. Population genetic analysis using additional – and more highly variable – molecular markers is needed to reveal pathways of dispersal in ocean currents and any barriers to genetic cohesion among Atlantic Ocean populations of this species.

W2-6974

Environmental genetic analysis of coral reef metazoan communities

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The impacts of human activity on the environment are of growing concern to society. Among these impacts, disturbance to biodiversity is one of the most important issues. However, our understanding of biodiversity, especially in ocean ecosystems, is very limited, and it is impossible to assess their condition with current information. In this context, we need further detailed information to assess the biodiversity of ocean ecosystems with accurate species identification, recognition of population structure, and genetic diversity. In this respect, we are conducting environmental genetic analyses of coral reef metazoan communities. For the collection of coral reef metazoans, we use Autonomous Reef Monitoring Structures (ARMS), which provides a standardized means of sampling. We recover these ARMS after one year of deployment, and collect all animals attached to the structure that is larger than 100μm. After collection, we extract DNA from the homogenized whole sample, amplify the target genes by PCR, and proceed to sequencing using Roche's 454 platform. Based on the diversity estimates obtained, we will assess and monitor coral reef metazoan diversity as well as the effects of anthropogenic disturbance, including climate change and ocean acidification.

W2-7037

Barriers in the pelagic: Population structuring of *Calanus helgolandicus* and *C. euxinus* in European waters

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Molecular studies of marine plankton have shown that ecological and/or environmental barriers play an important role in separating populations. Calanoid copepods are central in marine ecosystems and dramatic biogeographical shifts in copepod assemblages have been reported associated with recent climate warming. We examined spatial population structuring of *Calanus helgolandicus* and its sister species from the Black Sea, *C. euxinus*, based on genetic and morphometric characters. The aims were to identify barriers to dispersal, relate these to hydrographic characteristics, and to infer historical patterns of distribution and demography. We analysed a 408 base-pair fragment of the mitochondrial 16S gene, prosome to urosome length relationships, and sea surface temperatures obtained from 19 European sites. Estimates of genetic differentiation between samples and hierarchical analyses of molecular variance indicated strong spatial population structuring between, as well as within, basins. We identified seven phylogeographic groups: Fjords, Oceanic Inflow, NE Atlantic/Tyrrhenian, Adriatic/Ionian, Mljet Island, Aegean, and Black Sea, which explained 38.4% of the total genetic variation. Based on genetic data, *C. euxinus* is considered to be a differentiated population within the *C. helgolandicus* distribution range because the most important genetic barrier separates W and E Mediterranean populations. Surprisingly, NE Atlantic and W Mediterranean populations were not genetically differentiated. Morphometric barriers reflect sea surface temperature barriers and are not congruent with the main genetic barriers. Contrary to recent findings for *C. finmarchicus*, we conclude that *C. helgolandicus*/*C. euxinus* populations are not connected by high levels of dispersal and have been vulnerable to past climatic changes.

W2-7077

Adaptation in a changing antarctic environment: Transcriptomics of the southern ocean salp, Salpa thompsoni

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Salpa thompsoni is an important species in the pelagic ecosystem of the Southern Ocean. Climatic changes may favor salps over the keystone krill species, *Euphausia superba*. These changes may propagate up the Antarctic trophic web and thus have an effect on carbon flux to the deep sea. A promising approach to understanding whether and how the salp may adapt to climate change is the use of environmental genomics. This approach links responses of the living organism to environmental change at the molecular genetic level. An ongoing study is using 454 pyrosequencing of the salp genome to identify genes associated with key biochemical and physiological processes that underlay adaptation to environmental conditions. Collections of *S. thompsoni* were made during a January 2009 cruise of the Japanese research vessel *Umitaka-Maru* in the Pacific sector of the Southern Ocean. Analysis of genomic DNA to date has generated 38,740 sequences, which have been assembled and annotated by gene ontology to characterize their molecular function, biological process, and cellular component. We describe methods for transcriptome sequencing of *S. thompsoni*, as well as strategies for assembling useful catalogues of genes for ecological and environmental studies of pelagic tunicates and other non-model marine groups.

W2-7161

First insights into the molecular diversity of the North Sea zooplankton

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Marine zooplankton are considered good bio-indicators of climate change in the marine environment, and represent excellent "model organisms" for monitoring marine ecosystems. In order to characterize the zooplankton diversity in habitats showing the first indications of shifts in the zooplankton community as well as in seasonal occurrence and abundances, the temperate North Sea was chosen as our study area. This study of zooplankton diversity is being conducted in a recently started project on the coverage of the North Sea metazoan fauna at a molecular level. During May and November 2010 zooplankton samples were collected during several cruises in different regions of the North Sea. Numerous specimens of a variety of taxa have been collected and preserved for further molecular studies. After identification to the species level based on morphological characters, DNA barcodes (COI) are generated as well as alternative nuclear markers. This established database will serve as the basis for further approaches including metagenetic analyses of whole seasonal zooplankton samples. Preliminary results on the molecular diversity of zooplankton from different areas of the North Sea will be presented based on selected case examples.

W2-7317

Growth strategies of the invasive cladoceran *Cercopagis pengoi* in the Baltic Sea, and the molecular basis for its invasion success

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Despite ecological damage caused by introduced species and their effects on food webs in invaded ecosystems, the basis for invasion success remains elusive. To understand the relative importance of ecological, physiological and genetic mechanisms at different spatial and temporal scales and their contributions to a widespread ecological invasion, we examined ecological traits and their genetic basis in a highly invasive species – the cladoceran, *Cercopagis pengoi*. Recent studies suggest that the structure and copy number of rDNA have evolutionary and ecological significance through their effects on growth rate, resulting from their role in production of rRNA. We hypothesized that *Cercopagis* invasion success is due to increased allocation to sexual reproduction related to rearrangements in IGS rDNA at suboptimal environmental conditions and subsequent changes in RNA allocation, somatic growth and fecundity. This hypothesis was tested by examining life history traits and concurrent genetic variation using populations at different stages of invasion to explain invasion success.

W3 Posters

W3-6961

Seasonal dynamics of meroplankton assemblages at Station L4

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Zooplankton data from 20 years of weekly sampling were used to determine inter- and intra-annual patterns of meroplankton community change at Station L4, off the coast of Plymouth, UK. From these data, abundances were calculated for five groups; Cirripedia, Decapoda, Polychaeta, Echinodermata, and Lamellibranchiata. This taxonomic level of analysis was chosen to minimise the potential effects of variation in taxonomic expertise over the 20-year period. Despite some annual variability, analyses showed that seasonal variation accounts for the major changes in the meroplanktonic community composition throughout the time-series. Cirripedia are the most abundant meroplankton in March and April, followed by Echinodermata in August, and Lamellibranchiata in September and October. Abundance is low during the winter period. The average monthly contribution of the meroplankton community as a percentage of the total zooplankton abundance is highest in spring, when meroplankton (predominantly Cirripedia) account for up to 42.5% following spawning events linked to phytoplankton blooms. Little evidence was found for any major trends in the meroplankton community at Station L4 over the 20-year period. These data were then compared to a second time-series running from May 2008 to May 2009 that utilised molecular techniques in order to increase taxonomic discrimination, allowing a finer picture of annual and seasonal variation to be generated.

W3-7241

Multiscale temporal variability of *Eodiaptomus japonicus* in Lake Biwa

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Lake Biwa is the largest lake in Japan and has been strongly changed in its trophic structure and climatic variability during the last few decades. The Japanese endemic species *Eodiaptomus japonicus* is the sole calanoid copepod species and a dominant zooplankter in Lake Biwa. We compiled and analyzed long-term series data of its density and clutch size and some environmental parameters collected from the surface layer (0-10m) recorded at one monitoring station in the lake. First, the seasonal dynamics was investigated. Throughout the study period (1965 to 2005), *E. japonicus* exhibited strong seasonal cycles in abundance driven by temperature and resource availability, typically with major peak in early summer (May-June), second maxima in September, and minima in winter. Eggs are produced throughout the year following nevertheless a seasonal pattern with higher and lower production in spring and fall, respectively. At decadal scales, *E. japonicus* population showed high inter-annual variability from 1965 to 1980, with a pattern clearly characterized by alternate phases of increasing annual densities followed by an abrupt drop. In the long-term trend, the population density of *E. japonicus* was quite constant between 1965 and 1995, but a slight decreasing trend after 1995. Although the annual population density of *E. japonicus* remained rather stable throughout this 30 years period, the seasonal pattern varied between years. Inter-annual variability included slight shifts in the timing of density peaks and their magnitude. The source of such phenology changes was investigated in the framework of global change.

W4 Posters

W4-7111

Pteropod time series from the NE Pacific

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Pteropods are marine planktonic molluscs that play important roles as broad-spectrum microplankton grazers, and as prey for fish, squid, and for other plankton. Most species (*e.g. Limacina*, *Clio*) form aragonite shells. Other important species (*e.g. Clione*) lack shells but are narrow-spectrum predators that rely on shelled pteropods as their primary or exclusive prey. The entire group is therefore potentially threatened by increasing ocean acidification, which in some regions (including the NE Pacific and Arctic) is now approaching the solubility threshold for aragonite. Despite the grounds for ecological concern, there are few long-term time series of pteropod abundance. In this paper, we report time series of pteropod biomass anomalies off the Vancouver Island continental margin, and in the eastern Alaska Gyre (Line P). Off both southern and northern Vancouver Island, *Limacina* (the dominant subarctic thecate pteropod) has declined significantly. Continental margin trends for *Clione* (the dominant athecate) are non-significant. Occurrence rate, biomass and abundance of *Clio* (a subtropical species) have increased greatly, but these changes appear to be controlled primarily by circulation and/or temperature anomalies. The shorter (13-14 year) Line P time series as yet show no overall trends for any of the species, although occurrence of *Clio* is now also relatively frequent in the oceanic regions.

W4-7131

Effects of elevated CO_2 levels on the biochemical composition of Antarctic phytoplankton species and their quality as food for *Euphausia superba* larvae

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The Antarctic krill, *Euphausia superba,* is a key species in the Antarctic food web. Today a growing fishery and potentially negative effects of climate change put pressure on Antarctic krill populations. While ocean acidification may be a direct stressor for krill through decreased seawater pH and high levels of CO_2, this study aims to determine whether altered seawater carbonate chemistry will affect phytoplankton biochemical composition and therefore its nutritional quality as food for krill. The Antarctic diatom, *Synedropsis hyperborea*, was grown at ambient and 950ppm CO_2 and analysed for its lipid, carbohydrate and protein concentrations, pigment composition and growth rates. In subsequent feeding experiments with *Euphausia superba* calyptopis II larvae, in ambient CO_2 level seawater, krill mortality, growth rates, intermoult periods and lipid concentrations were measured. Preliminary findings indicated that concentrations of particulate organic carbohydrate and pigments in this diatom increased with elevated CO_2 levels, although pigment: chlorophyll *a* ratios did not change. Intermoult periods of calyptopis II larvae feeding on high CO_2 grown cells increased and growth rate decreased; larval behaviour was less vigorous, but mortality amongst individuals in the treatments was not different. These studies indicate that changes in phytoplankton biochemistry with elevated CO_2 levels may diminish their quality as food for krill. These sub-lethal effects in larval krill warrant further investigation including analysis of other ecologically important Antarctic phytoplankton species.

W4-7181

Impact of ocean acidification on the reproduction of coastal calanoid copepods

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Recent research effort has been directed towards understanding the potential implications of ocean acidification, but few studies have focussed on important holoplanktonic groups, such as calanoid copepods. Adult females of the species, *Centropages typicus* and *Temora longicornis* were incubated over four days at pH values ranging from 8.04 to 7.78 (corresponding to pH levels predicted to be reached by 2100) to investigate the potential effects of ocean acidification on their feeding rate, egg production, and hatching success. An additional incubation at pH 6.71 was also undertaken to address the implications of a CCS (carbon capture and storage) leak. Neither feeding rate, nor egg production and hatching success were affected at pH levels of 8.04 to 7.78 for both species. This was different for the CCS leak conditions, which appeared to cause a dramatic decrease in both egg production and hatching success over the incubation period, while feeding rate was variable with no obvious relation to pH. These results suggest that predicted low-pH conditions may not affect the reproductive output of these copepods in the short term, while CCS scenarios and long-term adaptability and resilience of key zooplankton species require further study.

W4-7188

The effects of CO_2-induced ocean acidification on the survival and development of early larval stage Antarctic krill (*Euphausia superba*)

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The Southern Ocean may show the earliest signs of ocean acidification due to the higher solubility of CO_2 in colder waters. Research into the biological effects of CO_2 has focussed on the aragonite saturation state of seawater, which is essential to marine calcifiers including pteropods, foraminifera and many benthic invertebrates. Despite the critical importance of Antarctic krill as a keystone species in the Southern Ocean ecosystem, the effects of elevated pCO_2 on krill have not been assessed. Krill larvae hatch at ~1km depth and must complete a developmental ascent to the surface waters as they progress through the first four larval stages (nauplius I & II, metanauplius and calyptopis I). This study investigated the effects of elevated pCO_2 (380, 700, 950 and 2000µatm) on these early larval stages. Significant effects were observed between 380 µatm and 2000µatm including a ~ 54% increase in mortality ($p<0.01$), a ~44% decrease in the proportion of larvae which successfully developed to calyptopis I and a ~72% reduction in the overall proportion of actively swimming larvae ($p<0.001$). The proportion of larvae surviving to calyptopis I with sufficient swimming ability to complete the developmental ascent decreased ~35% at 950µatm and ~66% at 2000 µatm ($p<0.05$). Recent research suggests that pCO_2 at the depths associated with larval krill development may reach 1000-2000 µatm within this century. These results imply significantly reduced larval recruitment under elevated pCO_2 which would have major implications for Southern Ocean ecosystems and the krill fishery.

W5 Posters

W5-7149

Application of automated image identification in the Jiaozhou Bay zooplankton ecological study

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Zooplankton play an important role in marine ecosystems. How to identify zooplankton samples rapidly is a key problem in zooplankton ecological studies. Automated zooplankton image identification is a rapid and standard method developing in recent years. However, this technique hasn't been used efficiently in national zooplankton research. By combining the ZooScan, ZooProcess and Plankton Identifier, we used the automated image identification method in Jiaozhou Bay for the first time. A learning set of Jiaozhou Bay zooplankton images was set up according to the dominant zooplankton composition. Results of the performance test indicated that the accuracy was higher than 80%, and the misidentification was lower than 20% for most zooplankton groups. For the groups of: copepods, chaetognatha, *Noctiluca*, *Euphausia* and *Coscinodiscus*, the accuracy was higher than 90%. By comparison of the results of automated identification and manual identification, there are very significant correlation between the two methods among the five dominant groups, especially for the groups copepods and chaetognatha, and the r^2value reached 0.96 and 0.75, respectively. The automated analysis was further used for the study of biovolumes and size spectra of zooplankton, which improved the methods used for studying zooplankton ecological and long-term change of the Jiaozhou Bay ecosystem efficiently.

W5-7186

Biomass structure of the mesozooplankton in the coastal upwelling system off central-southern Chile during the spring 2004 as assessed by automated image analysis

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We assessed the biomass structure of the mesozooplankton community under the influence of coastal upwelling during austral spring 2004 in the coastal upwelling zone off central-southern Chile. Biomasses as structured by taxa were derived by using the ZooImage analysis of digitalized zooplankton samples obtained from the upper 200 m covering the continental shelf and offshore water in the upwelling zone. Zooplankton spatial distribution was associated with the upwelling filament, although with a significant day vs. night effect explained by diel vertical migration. Copepods and euphausiids were the major contributors to biomass and *Euphausia mucronata* and large-sized Eucalanidae copepods were dominant components. The log-normalized biomass spectra significantly fitted a linear regression and whose slope was correlated with oceanographic variables driven by coastal upwelling. The Shannon diversity index applied to taxa classification derived from ZooImage and weighed by taxa biomasses was strongly correlated to oceanographic variability, suggesting that coastal upwelling is a key processes structuring the spatial diversity at a mesoscale level, and therefore upwelling intensity may control the biomass spectra in this region. Our findings suggest that physical-chemical heterogeneity of the coastal-offshore zone driven by upwelling is a crucial factor to maintain zooplankton composition and its spatial distribution.

Author Index

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

X

Y

Z

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(as of January 26)

* *denotes non-attending registrants whose posters are presented by colleagues or co-authors*

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Photo of a giant jellyfish, *Chrysaora* sp.,
taken in the Pacific Ocean off California, USA

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