

Census of Marine Zooplankton (CMarZ)

P.I. Ann Bucklin, Professor
Department of Marine Sciences
University of Connecticut - Avery Point
1080 Shennecossett Road
Groton, CT 06340 USA
Tel. +1 860-405-9208; Fax +1860-405-9153; Email: ann.bucklin@uconn.edu

Co-P.I. Shuhei Nishida, Professor
Ocean Research Institute, University of Tokyo
1-15-1 Minamidai, Nakano, Tokyo 164, JAPAN
Tel. +81 (3) 5351 6475, Fax +81 (3) 5351 6481, Email: nishida@ori.u-tokyo.ac.jp

Co-P.I. Sigrid Schiel, Professor
Marine Animal Ecology
Alfred Wegener Institute for Polar and Marine Research
D 27568 Bremerhaven, GERMANY
Tel. +49 (471) 4831 1303, Fax +49 (471) 4831 1149, Email sschiel@awi-bremerhaven.de

Project website: www.CMarZ.org

1. 2006 ACCOMPLISHMENTS & SCIENTIFIC HIGHLIGHTS

- *Species discovery in SE Asia*: Shared efforts for sampling and species description by the member countries and taxonomic experts of a CMarZ cooperating project funded by the Japan Society for the Promotion of Science (JSPS) have resulted in discovery of 3 new genera and 19 species of previously undescribed copepods and mysids have been discovered from SE Asian coastal waters during the past two years. [CMarZ contact: Shuhei Nishida]
- *SPICE analysis of time/space variability*: Zooplankton samples showed clear differences in species composition and diversity among stations between coastal and offshore stations near the Spermonde Archipelago in Indonesia. Expert taxonomic analysis is yielding new knowledge of species found in this ‘center of biodiversity’. [CMarZ contact: Sigi Schiel]
- *DNA barcoding*: Identified alcohol-preserved specimens have been catalogued for DNA sequencing of a target gene. Specimens have been obtained from CMarZ, ArcOD, and MAR-ECO cruises. To date, nearly 500 species of holozooplankton have been barcoded. Results are being readied for publication and GenBank release. [CMarZ contact: Ann Bucklin]
- *Species discovery in the deep sea*: A CMarZ/NOAA Ocean Exploration cruise during April 2006 yielded samples from meso-, bathy-, and abyssopelagic waters of the NW Atlantic Ocean (Sargasso Sea), with more than 500 species identified. Identified specimens were prepared for barcoding, with an onboard automated DNA sequencer producing barcodes for ~100 species during the cruise. Experts speculated that 12 new species were found among diverse zooplankton groups. [CMarZ contacts: Peter Wiebe and Larry Madin]

- *Zooplankton of Middle Eastern seas*: Regular sampling was carried out in the Eastern Mediterranean, Black and Caspian Seas. Enormous phytoplankton levels were observed in the Caspian Sea, resulting from bulk removal of zooplankton by an invading ctenophore and demonstrating the importance of zooplankton grazing in an ecosystem. [CMarZ contact: Ahmet Kideys]
- *WoRaDD (World Radiolarian Distributional Database)*: Identification and location of the sources of information is 90% completed. The distributional database now includes data from 3,851 samples, including 1118 plankton (net or pump) samples, 492 sediment trap samples, and 2240 sediment samples. [CMarZ contact: Demetrio Boltovskoy]

2. SOCIETAL BENEFITS, IMPACT & APPLICATIONS

CMarZ results have practical real-world applications for diverse issues:

- *Indicators of ecosystem health*: Knowledge of prior and existing patterns of zooplankton distribution and diversity is useful for management of coastal marine ecosystems. Zooplankton diversity can be used as a measure of the status, functioning, and health of marine ecosystems.
- *Baseline biodiversity assessment*: A global assessment of marine zooplankton biodiversity will provide a benchmark against which future changes resulting from climate change or other anthropogenic or natural variation can be measured. The baseline will include exploration of ocean regions and taxa that have historically been ignored or understudied, and are thus likely to yield new species discovery.
- *Ocean observing systems*: The CMarZ effort to determine DNA barcodes for zooplankton species is yielding data needed to produce DNA microarrays (“chips”), which can be used for automated and/or remote identification and quantification of zooplankton. In the not-too-distant future, ocean observing stations may include moored instruments with DNA-based detection systems for in situ identification of species.
- *Marine bioinvasions*: Species invasions are occurring with ever-increasing frequency, particularly in coastal waters.
- *Fundamental science issues*: Zooplankton are significant mediators of global elemental cycles, including fluxes of carbon, nitrogen, and other critical elements in ocean biogeochemical cycles. Patterns of endemism are fundamental to understanding how geographic ranges may change over time, how new species may arise, and what may cause extinction of species in the ocean. Since the majority of pelagic species are rare, zooplankton can be used to evaluate the significance of rare species for ocean food web stability.

3. WORK PLANNED FOR 2007

Two comprehensive biodiversity survey cruises for CMarZ will be carried out during 2007:

- *Inner-space Speciation Project*: Zooplankton samples will be collected using nets and ROVs during an expedition to the Malaysian waters during 2007. Funded by NOAA Ocean Exploration, the National Geographic Society and Conservation International. [E1; CMarZ contact: Larry Madin]
- *Atlantic meridian transect*: A north-to-south latitudinal transect throughout the Atlantic Ocean is planned for October/November 2007. Sampling from the *R/V Polarstern* will be done with a Multinet, including deep samples below 2000m. [E7; CMarZ contact: Sigi Schiel]

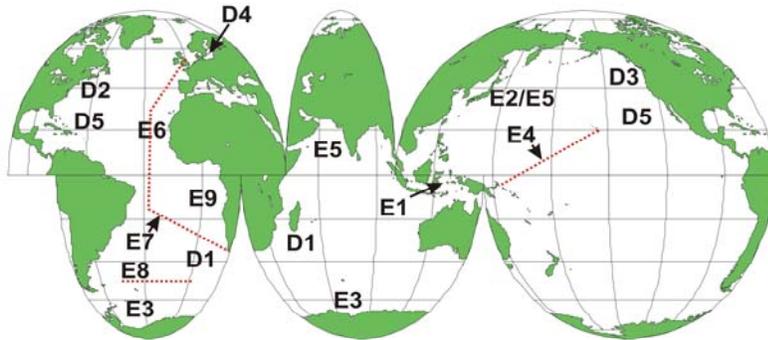


Figure 1. CMarZ cruises of opportunity planned for 2007. Sampling activities indicated by “D” are ongoing time-series collections; “E” indicates cruises scheduled during 2007.

In addition, CMarZ researchers, staff, and students will participate in cruises of opportunity during 2007 (Figure 1). Such cruises are an essential element in meeting the CMarZ goal of global coverage for sampling and analysis by 2010.

Laboratory-based activities – including sample and data analysis, techniques development, database development, and website design and construction – are essential elements of CMarZ. Planned cooperating projects for 2007 include:

- *World Radiolarian Distributional Database (WoRaDD)*: This project is compiling all the existing (published and unpublished) information on radiolarian (Polycystina) distributions from plankton and sediment trap samples, and from surface sediment materials. [CMarZ contact: Demetrio Boltovskoy]
- *Calcareous Plankton Ocean Biogeographical Information System (CalcOBIS)*: The CalcOBIS database is an interactive biogeographical system that will provide global taxonomic and phylogenetic information at the morphological and genetic species levels for all calcareous skeleton-bearing taxa. [CMarZ contact: Colomaban de Vargas]
- *DNA Barcoding*: Laboratories associated with CMarZ and equipped for molecular analyses (including DNA sequencing) will coordinate to ensure storage, archiving, and molecular systematic analysis of specimens sent by CMarZ researchers, who may be focused on taxonomic, morphological, or ecological studies. A DNA sequence appropriate for species identification and discovery (i.e., a DNA barcode) will be selected for each zooplankton taxon. Specimens will be sequenced within a reasonable time frame, and the DNA sequences submitted to the GenBank molecular database (<http://www.ncbi.nlm.nih.gov>). Voucher specimens and voucher DNA will be permanently maintained by the molecular laboratory, and will be accessible for further study. [CMarZ contacts: Ann Bucklin and Shuheh Nishida]
- *Calanoides carinatus ZooGene Project (CCZP)*. This project seeks to determine the taxonomic limits of the polymorphic copepod species, *Calanoides carinatus*, using coordinated

morphological and molecular analysis of specimens. This effort was designed and led by Maria Delia Vinas (INIDEP, Argentina). [CMarZ contacts: Ann Bucklin and Hans Verheye]

- *Deep phylogeny of Calanoid copepods*: This collaboration compares morphological and molecular evidence of the relationships among calanoid copepods. Molecular analysis includes DNA barcoding and sequencing slowly-evolving genes revealing deeper evolutionary relationships. [CMarZ contacts: Janet Bradford-Grieve, Shuhei Nishida, Ann Bucklin]
- *International Indian Ocean Expedition (IIOE) data digitization*: This continuation of an ongoing project will produce digitized inventories for major groups of zooplankton in the Indian Ocean, with complete morphological descriptions of species, known biological distributions, and a comprehensive bibliography. [CMarZ contact: Vijayalakshmi Nair]

4. EDUCATION & OUTREACH

CMarZ Network: In order to expand CMarZ participation beyond the Steering Group and their students and staff, CMarZ seeks members for the CMarZ Network. The particular target is expert taxonomists, although students and parataxonomists are encouraged to join. The Network now includes 42 members (see www.CMarZ.org). Network participation helps encourage and facilitate participation in CMarZ field and laboratory activities. The CMarZ Network also helps coordinate analysis of existing and newly-collected zooplankton samples by identifying appropriate experts for particular taxonomic challenges, and requesting their assistance.

CMarZ Training Workshops: CMarZ sponsored several international training workshops, both on land and at sea, during 2006:

- A workshop-at-sea was organized by Peter Wiebe, Tracey Sutton, and Martin Angel during a CMarZ / NOAA Ocean Exploration cruise on the R/V *Ronald H. Brown* in the NW Atlantic (Sargasso Sea) during April 2006. Lectures, demonstrations, and one-on-one training focused on morphological and molecular taxonomic analysis.
- *DNA Barcoding for CoML* workshop was convened during May 2006 in Amsterdam, the Netherlands. Hosted by Annelies Pierrot-Bults and organized by Ann Bucklin and others, with a number of participants from CMarZ.
- *Day on species richness*: A public two-day event focusing on marine life of the North Sea and designed for students and the press, this activity is conducted each year by GEO, a popular German magazine (with cooperation from AWI in 2006). Held in June 2006, a day cruise is included, with CMarZ researchers leading efforts to produce a zooplankton species list. [CMarZ contact: Sigi Schiel]

To date, more than 100 students, staff, and researchers have participated in CMarZ workshops.

Graduate/professional training: CMarZ has created opportunities for graduate and professional training through the activities of Steering Committee members. International exchanges by students, post-doctoral fellows, and researchers add a particularly compelling element to graduate training for CMarZ. During 2006, Rosamma Stephen (NIO, Kochi, India) offered training classes in copepod

identification at the Alfred Wegener Institute (Germany) and the Woods Hole Oceanographic Institution (USA) during July, 2006; Usha and Subhash Goswami (NIO, Goa, India) visited UConn during July, 2006; and Leocadio Blanco Bercial, a graduate student at the University of Oviedo (Spain) visited UConn during May 2006.

Secondary school teachers and students: Several Steering Group members are engaged with teachers and/or host teachers' workshops relevant to their research activities. In particular:

An ARMADA Teacher-at-Sea, Joe Catron, participated in a CMarZ/NOAA Ocean Exploration cruise on the R/V Ron Brown to the NW Atlantic (Sargasso Sea) led by Peter Wiebe. Joe sent messages from sea to his students at West High School in Billings, Montana, USA.

German High School students participated in a cruise of the traditional sailing ship Roald Amundsen to the Atlantic seamounts. They were introduced to zooplankton and sampling methods by CMarZ participants Sigi Schiel and Astrid Cornils.

Public education and media relations: The CMarZ website provides background information on zooplankton for the general reader, and vivid imagery of zooplankton helps build and maintain public interest. CMarZ continues to draw media interest, perhaps largely because of the compelling images of living zooplankton. A CoML press event designed by Darlene True Crist and others for the April 2006 CMarZ / NOAA Ocean Exploration cruise led by Peter Wiebe yielded more than 100 articles, with coverage in 25 countries and 10 languages.

5. GEOGRAPHIC EXPANSION

From a practical perspective, a global census of zooplankton biodiversity requires effective international cooperation. CMarZ has ensured this by establishing a network of regional centers. CMarZ observation and collection protocols are standardized and quality-controlled, in order to ensure comparability of results among different field efforts. A global perspective is being derived from comparisons among regions and taxa. Conceptual, modeling, and statistical approaches are being used to synthesize findings from independent studies.

CMarZ is well along in sampling and analysis throughout all ocean basins. Additional effort is needed in under-sampled regions (SE Asia) and domains (meso- to abyssopelagic). Sampling these regions – which is critical to meeting the CoML challenge for completeness – will require additional dedicated CMarZ cruises, which allow targeted sampling and participation by many Steering Group members and expert taxonomists with their students and staff.

Our overall approach to ensuring global coverage for sampling and analysis includes several elements:

- Use of existing data: An essential element of CMarZ is to ensure that data from existing databases are used to construct our global understanding of the distributions of zooplankton species.
- Use of existing zooplankton collections: Archived zooplankton samples are an invaluable resource for CMarZ. For some groups – excluding some gelatinous forms – such samples contain a record of ocean zooplankton assemblages at known points in time and space.

- **Ships of opportunity:** A pre-eminent example of the power of ship-of-opportunity sampling is the Continuous Plankton Recorder (CPR) survey, the longest-running, basin-scale plankton monitoring survey in the world. In addition, CMarZ researchers join planned oceanographic cruises in many ocean regions. Commercial fishing vessels also provide cost-effective means to sample zooplankton, especially in coastal regions in association with particular fisheries.
- **Taxonomically-comprehensive biodiversity surveys:** Global surveys of exploration and discovery for marine zooplankton necessarily require dedicated ship-time for cruises in targeted regions of the world oceans. Transit legs of oceanographic research vessels are a cost-effective platform for such sampling.
- **Partnerships with national fisheries agencies:** CMarZ has agreements in place for zooplankton collections during resource and environmental surveys by US National Marine Fisheries Service (NMFS); the Marine Research Institute (Reykjavik, Iceland); and the Institute of Marine Research (Bergen, Norway). We anticipate that similar agreements will also be possible in other countries and regions (e.g., Argentina, Chile, and the European Union).

6. PARTNERSHIPS & COLLABORATION

a. Partnerships

Organization Name	Point-of-Contact	Nature of Relationship
NOAA National Marine Fisheries Service (US government)	David Mountain, NMFS Northeast Fisheries Science Center, Woods Hole, MA	Zooplankton sampling from NMFS Ecosystem Surveys
Hokkaido University	Naonobu SHIGA, Plankton Laboratory, Graduate School of Fisheries, Hokkaido University	Zooplankton collection and database from Subarctic Pacific
Tokai University	Shozo SAWAMOTO, Institute of Oceanic Research & Development, Tokai University	Zooplankton collection and database from CSK
Fisheries Research Agency (Japanese government)	Hiroya SUGISAKI, Tohoku Regional Fisheries Research Institute	Zooplankton collection and database from Odate Project
Oceanographical Society of Japan	Nozomu IWASAKI, Committee for Educational Issues, Oceanographical Society of Japan	Education and outreach for children and students
Japan Agency for Marine-Earth Science and Technology	Dhugal J. Lindsay, Extremobiosphere Research Center	Deep-Sea zooplankton study, collection, and database from DSRVs and ROVs
Marine and Coastal Management, Dept of Environmental Affairs and Tourism (South African government)	Hans Verheye, Ocean Environment (Biological Oceanography), Cape Town, S. Africa	Zooplankton sampling during annual fish stock assessments and monthly environmental monitoring programs
National Marine Information and Research Centre, Ministry of Fisheries and Marine Resources (Namibian government)	Anja Kreiner, Environmental Section (Biological Oceanography), Swakopmund, Namibia	Zooplankton sampling during annual fisheries surveys and monthly environmental monitoring programs

National Marine Research Institute (Angolan government)	Antonio da Silva, Luanda, Angola (now Swakopmund, Namibia)	Zooplankton sampling during monthly environmental monitoring programs
---	--	---

b. Links to Other CoML Ocean Realm Projects

Project Name	Cross-Over Person(s)	Nature of Relationship
ARCoML	Russ Hopcroft, Ann Bucklin	ARCoML collects and analyzes samples; CMarZ determines DNA barcodes and serves data.
ICOMM	Demetrio Boltovskoy, Colomaban de Vargas	Members of a joint CMarZ-ICOMM Coordinating Committee .
MAR-ECO	Ann Bucklin, Peter Wiebe	CMarZ analyzes samples and determines DNA barcodes for specimens from MAR-ECO

c. Links to CoML National and Regional Implementation Committees (NRICs)

NRIC	Liaison or Cross-over personnel	Nature of Relationship
Australia		
Canada		
Caribbean		
China	Sun Song (Chinese Acad Sci)	Point of contact for CMarZ activities
Europe	Sigrid Schiel (AWI)	Point of contact for CMarZ activities
Indian Ocean	Vijayalakshmi Nair (NIO)	Point of contact for CMarZ activities
Japan	Shuhei Nishida (ORI)	Point of contact for CMarZ activities
South America	Ruben Escribano (Univ Concep)	Point of contact for CMarZ activities
Sub-Saharan Africa	Hans Verheye (Res Aquarium, SA)	Point of contact for CMarZ activities
USA	Ann Bucklin (UConn)	Point of contact for CMarZ activities

d. Liaisons to CoML Cross-Cutting Groups

Project Name	Liaison Name & Institution	Nature of the Relationship
OBIS	Ann Bucklin (UConn)	Member of OBIS International Committee
HMAP		
FMAP	Larry Madin (WHOI)	FMAP-funded project
SCOR Tech Panel	Ann Bucklin (UConn)	Coordinated co-sponsorship of DNA barcoding workshop
E&O	Nancy Copley (WHOI)	CMarZ Communications coordinator is a member of CoML E&O Network
Barcoding	Ann Bucklin (UConn)	Coordinator for "DNA Barcoding for CoML" Workshop; facilitating CMarZ laboratories to join CBOL