Census of Marine Zooplankton: A New Global Survey of Marine Biodiversity

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The Census of Marine Life (CoML) is surveying marine biodiversity to gain an accurate understanding of the diversity, geographic distribution, and abundance of marine species – from pole to pole, coastal estuaries to open ocean, and surface to the abyss. By 2010, CoML field projects will integrate and synthesise their discoveries and conclusions, and thereby produce a new global view of the diversity of life in the ocean. This comprehensive information – the answers to the "who, where, and how many" questions about marine life – is critical for observing, measuring, and understanding the impacts of global change.

The Census of Marine Zooplankton (CMarZ) is a new CoML field project designed to work towards a taxonomically comprehensive assessment of biodiversity of animal plankton throughout the world ocean. The project goal is to produce accurate and complete information on zooplankton species diversity, biomass, biogeographical distribution, genetic diversity and community structure by 2010. The taxonomic focus is the animals that drift with ocean currents throughout their lives (i.e. the holozooplankton). This assemblage currently includes about 6,800 described species in fifteen phyla, however, it is expected that several new species will be discovered as a result of CMarZ.

CMarZ will result in more complete knowledge of biodiversity hotspots and unexplored ocean regions, new understanding of the functional role of biodiversity in ocean ecosystems, and better characterisation of global-scale patterns of marine zooplankton biodiversity. CMarZ will contribute to the fundamental understanding of biogeochemical transport, fluxes and sinks; productivity of living marine resources; and structure and function of marine ecosystems.

At present, we do not know how differences in the diversity of marine communities impact flows of energy and matter through marine food webs. The new IGBP project – IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) – will seek to unravel this interrelationship, and will require accurate and comprehensive descriptions of biodiversity. Describing and understanding species-level biodiversity are important aspects of IMBER's scientific goals and objectives, which include understanding how species diversity impacts, determines, and/or drives global elemental cycles, food web structure and ecosystem stability, transfer of organic matter from the photic zone to deep waters, and biogeochemical feedback processes that control the carbon cycle.

The scientific rationale for CMarZ includes topics that are fundamental for IMBER and other IGBP projects, including:

- *Functional consequences for marine ecosystems.* Shifts in the relative abundances of important species can be propagated through the food web. Short-term shifts in zooplankton species composition and biomass have been associated with El Niño or La Niña [1], and zooplankton species have shown persistent shifts in abundance in the northeast Pacific [2]. In the northeast Atlantic, distributions of copepod species (Figure 1) [3] and planktonic food web dynamics [4] have been shown to shift with decadal climate variability. Altered copepod species composition can dramatically alter the biological pump – i.e. the export of carbon from surface waters into the ocean's interior [5]. In the Antarctic, polar warming and a decrease in sea-ice cover have been associated with changes in the relative importance of Antarctic krill and salps [6], species that play central roles in the Southern Ocean food web.

- *Global elemental cycles.* Marine zooplankton are significant mediators of fluxes of carbon, nitrogen and other important elements in ocean biogeochemical cycles [7]. It has been recognised for many years that changes in the species composition of zooplankton assemblages have strong impacts on rates of recycling and vertical export [8]. Long-term changes in fluxes into the deep sea [9] may be related to zooplankton species composition in overlying waters [10].

Figure 1. The copepod, *Calanus hyperboreus*. (Photograph: R.R. Hopcroft, University of Alaska, USA).

- *Marine bio-invasions*. Species invasions are occurring with ever-increasing frequency, particularly in coastal waters [11]. Non-indigenous gelatinous species have negatively affected ecosystems throughout the world. A spectacular example of this phenomenon is the inadvertent introduction of the ctenophore *Mnemiopsis leidyi* into the Black Sea – and now the Caspian Sea – presumably by transport in ballast water. The resultant perturbation of the food web included devastation of Black Sea and Caspian Sea fisheries [12]. In the Bering Sea, an enormous increase in jellyfish biomass, dominated by the scyphozoan *Chrysaora melanaster*, is likely to have consequences for groundfish fisheries [13]. Gelatinous zooplankton species (see Figure 2) have been reported to form blooms with deleterious effects on ecosystems and fisheries in Japanese waters, the eastern Mediteranean Sea, the North Sea, estuaries in Argentina, and elsewhere.

- *Food web stability.* The majority of pelagic species may be consistently rare [14]. It cannot be assumed that these species play a negligible role in community dynamics, although theories from terrestrial studies argue for this view. In recent years, theoretical ecologists have found that food webs containing many species with weak trophic interactions exhibit greater ecological stability than those having few species with strong interactions [15]. This result and ongoing research suggest that rare species may play an important role in stabilising communities over time. Species dominance patterns may also change through time: previously rare species may become predominant, and *vice versa*. The ecology of rare species needs to be better understood, in order to work toward genuine understanding of community and ecosystem dynamics, especially the effect of rare species on foodweb stability.

- *Baseline biodiversity assessment.* There is an urgent need for a global baseline assessment of marine zooplankton biodiversity. Changes in the ocean environment and the availability of new methods to observe, analyse, and monitor zooplankton species make such a global census both feasible and necessary. A baseline assessment will provide a contemporary benchmark against which future changes can be measured.

CMarZ will begin by coordinating with ongoing, planned, and proposed oceanographic field programs. Such coordination will provide opportunities for sampling zooplankton taxa in many ocean regions during the first years of the project. Sampling design will be optimised using theoretical and numerical models, in collaboration with the FMAP (Future of Marine Animal Populations) project of CoML. Sampling systems will include traditional nets and trawls, remote detection, optical sensors, and integrated sensor systems deployed on towed, remotely-operated, or autonomous vehicles and submersibles. New sampling methodologies will be required to collect and study rare and fragile organisms which are less well known. CMarZ will also make use of existing data and archived zooplankton collections. CMarZ will benefit from molecular approaches, including DNA sequences for target regions to be used for species identification (i.e. DNA "barcodes"; see www.barcodinglife.com). DNA micro-arrays and gene expression analysis. Molecular protocols can be used to identify key species and / or functional groups, and to increase our knowledge of the structure and function of marine food webs.

A primary product of CMarZ will be a distributed database of species names, collection information, voucher and specimen locations, DNA sequences, images and other information. The CMarZ database will be fully integrated with, and searchable from, the Ocean Biogeographical Information System (OBIS) portal (see www.iobis.org). CMarZ will train graduate students and professionals, who will enhance capacity for taxonomic identification of species of zooplankton groups. CMarZ will build public appreciation for the value of marine biodiversity with dissemination of information via web pages, presentations, and printed materials for students, research-

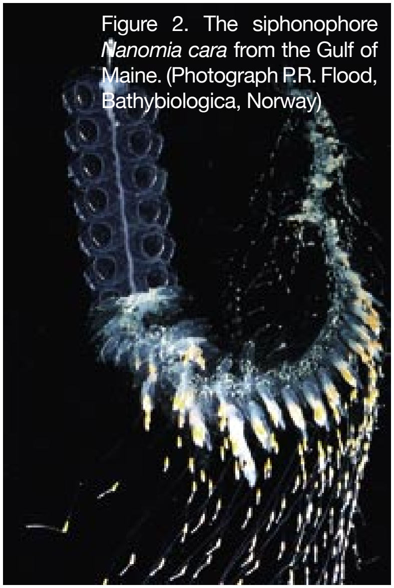

Figure 2. The siphonophore *Nanomia cara* from the Gulf of Maine. (Photograph P.R. Flood, Bathybiologica, Norway)

ers, and general audiences, as well as peer-reviewed scientific publications.

CMarZ will require international collaboration and coordination, through a distributed network of program centres, field project participants, students and laboratory technical staff and taxonomic specialists. CMarZ will establish project offices in North America, Europe and Asia to provide scientific leadership, planning and implementation of field activities, and coordination of proposals and fund raising activities. For more information, the CMarZ Science Plan can be downloaded from the CoML portal (www.coml.org) or the CMarZ project website (plankton.unh.edu).

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