



Preface

Introduction to species diversity of marine zooplankton

1. Introduction

Understanding ocean ecosystem dynamics and predicting changes over time requires knowledge of zooplankton species diversity, distribution, and abundance throughout the world's oceans. The fundamental question "What lives in the Ocean?" has been the focus of research by taxonomists and ecologists since the dawn of marine science marked by the Challenger Expedition in 1872 to 1876 (McGowan, 1971, 1972). This was emphasized by Russell (1935, pages 6, 7): "Before any work on the biology of animals can be attempted, the animals that we wish to study must be described and classified. This is a task that has gone on from the earliest days of marine science...". He went on to say "Many years must elapse before the description of all the species of plankton animals is brought to completion". More than 75 years later, this task is not yet completed. The Census of Marine Life Program (CoML) was created in recognition of the fact that much work remained in order for a baseline of species presence to be created that would enable the effects of climate change to be assessed. Marine zooplankton are important indicators of environmental change associated with global warming and acidification of the oceans and recent large-scale shifts have been observed or are anticipated in portions of the species ranges of plankton throughout the world's oceans i.e. in the North Atlantic (Beaugrand et al., 2009; Reid et al., 2009; Bonnet et al., 2007; Valdes et al., 2007), in the Pacific (McGowan et al., 1998; Checkley and Barth, 2009), and in the Southern Ocean (Murphy et al., 2007). As one component of CoML, the Census of Marine Zooplankton (CMarZ) has been working toward a global-scale, taxonomically-comprehensive assessment of species diversity of holozooplankton, those plankton that spend their entire life living in the water column. It is estimated that there are ~7,000 known species of holozooplankton in 15 phyla (Bucklin et al., 2010) and perhaps as many more remain to be discovered.

This volume represents contributions from participants in CMarZ who have been involved in the program's at-sea collections and others who have had access to existing samples produced by related programs. During the seven-year duration of the program (2004 to 2010), many samples have been collected as part of routine marine surveys in national waters that will enable the distribution and abundance of species to be determined. Many remain to be examined. In addition, an international team of taxonomists and molecular specialists participated in two CMarZ dedicated expeditions to the subtropical/tropical western North Atlantic (RV R. Brown, April 2006) and the subtropical/tropical eastern Atlantic (RV Polarstern, November 2007, ANT-XXIV/1). Both cruises were uniquely-equipped with 10-meter MOCNESS

with fine mesh nets (333 μ m mesh) that allowed CMarZ scientists to sample to $\geq 5,000$ meters in the North and South Atlantic Ocean and rapidly filter large volumes (tens of thousands of cubic meters) to capture rare deep-sea zooplankton and fish (Wiebe et al., 2010) in addition to a variety of other sampling systems. The collections included first-ever observation of living specimens of rare deep-sea species (e.g., Johnson et al., 2009; Bradford-Grieve, 2010; Pagès and Madin, 2010), and offered remarkable opportunities for photographing living specimens (Cover Photo this volume). On both cruises instrumentation was on board the vessels that enabled genetic sequencing of the genes used to uniquely identify species and many sequences were produced (Bucklin et al., 2010; Jennings et al., 2010). Other CMarZ field efforts have included extensive sampling throughout all ocean basins, including hot spots of species discovery in the Indo Pacific.

These papers represent the results of the multi-year effort to determine what lives in the ocean. The first set are those that describe specific pelagic species groups (Copepods, Chaetognaths, and Medusozoa) found in a number of World Ocean regions. Schnack-Schiel et al. (2010), Cornils et al. (2010) and Hidalgo et al. (2010) investigate the abundance, distribution, diversity, and community structure of copepods in relation to environmental conditions in three different geographical regions: in the subtropical/tropical Eastern Atlantic, in the Spermonde Archipelago, Indonesia, and in the Chilean upwelling system.

Three manuscripts deal with single copepod taxa. Matsuura et al. (2010) study the vertical distribution pattern of *Euaugaptilus* species in two contrasting areas: the Sulu and the Celebes Seas; Goetze and Ohman (2010) report on the biogeography of the *Eucalanidae* and combine molecular and morphological methods; and Machida and Nishida (2010) investigate the genetic isolation of the mesopelagic copepod *Disseta palumbii*. Nair and Gireesh (2010) describe the diversity of chaetognaths of the Andaman Sea, and Ortman et al. (2010) the DNA barcoding of Medusozoa.

The second set of papers describes the results from the two CMarZ dedicated cruises in the western and eastern Atlantic Ocean. It includes an account of new copepod species (Bradford-Grieve, 2010), an inventory of ostracods in the North Atlantic (Angel, 2010), diversity patterns of chaetognaths, gastropods, and mid-water fish (Pierrot-Bults and Nair, 2010; Miyamoto et al., 2010; Jennings et al., 2010; Sutton et al., 2010), and the development of a "Rossetta Stone" for identification of zooplankton using combined morphological analyses and genetic technologies (Bucklin et al., 2010).

There are many areas of the world's oceans that remain to be explored and the species identified, especially the waters below 1000 m and extending to the deep-sea floor 5000 m and more

below the surface including the benthic-pelagic habitat. In addition, many oceanic species have been listed as occurring in the Indian, Pacific, and Atlantic oceans; how many of these involve cryptic species that await discovery? There are more new species, cryptic or otherwise, likely to be discovered in continental shelf and coastal waters from the poles to the equator. It is critical that descriptions of newly discovered species include detailed morphological information, key molecular characters (barcode), and high resolution images. The knowledge of the distribution and abundance of zooplankton species world-wide is essential for evaluating the impacts of climate change marine ecosystems.

For more information about the Census of Marine Zooplankton go to <http://www.cmarz.org/> and about the Census of Marine Life go to <http://www.coml.org/>.

2. Dedication

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This volume is dedicated to the memory of our friend and colleague Francesc Pagès, who died unexpectedly on May 5, 2007, just about a year after he participated in the CMarZ Sargasso Sea expedition on the R/V. Ron Brown (Fig. 1). That cruise included several specialists in gelatinous zooplankton, but Francesc was one of the most diversified, accomplished, and enthusiastic in that field, with an international reputation in taxonomy and ecology of medusae and siphonophores, and with broad interests in other organisms and phenomena. The excitement he found in discovering and describing gelatinous animals, whether new species or old friends, was consistent and infectious. Francesc was a great

shipmate, always willing to ask or answer questions, always seeking new observations and insights. We all looked forward to many future cruises, meetings, visits, and dinners with Francesc.

The short note included in this volume (Pagès and Madin, 2010) is based on an observation Francesc made that others on the cruise had scarcely noticed. His knowledge of siphonophore taxonomy and his curiosity about their feeding behavior allowed him to make the observation and understand its implications for pelagic trophic ecology.

All who knew Francesc miss him as a friend, colleague, and great scholar of zooplankton, who left us long before his time. An obituary (Gili et al., 2009) and bibliography (Youngbluth, 2007) have been published elsewhere.

Cover Image: Images of a variety of holozooplankton. Photos by Cheryl Clarke-Hopcroft and Russ Hopcroft, University of Alaska, Fairbanks; and Larry Madin, Woods Hole Oceanographic Institution. These organisms range in size from 1 to 40 millimeters and are not to scale. The figure and the illustrated legend were designed and produced by Katherine Spencer Joyce, Graphics illustrator, Woods Hole Oceanographic Institution.

Illustrated Legend: Line drawings of the cover zooplankton and their names.

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Fig. 1. Francesc Pagès at sea on the R/V Ron Brown 19 April 2006.

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