Jellyfish Blooms: Causes, Consequences, and Recent Advances

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Jellyfish Blooms: Causes, Consequences, and Recent Advances

Proceedings of the Second International Jellyfish Blooms Symposium, held at the Gold Coast, Queensland, Australia, 24–27 June, 2007

Editors

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Cover illustration: An aggregation of the giant jellyfish, *Nemopilema nomurai*, in a set net in Kyoto Prefecture, Japan. Photo by Yomiuri Shinbun.

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Preface

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Jellyfish are among the most conspicuous animals in the ocean. They are fascinating ecologically as they are major consumers of zooplankton, are widely distributed, and most have complex life histories and demographics. They also have societal and economic significance as they clog cooling water intakes of coastal industries and ships, interfere with fisheries and deter holidaymakers from enjoying a swim at the beach. Although it is not a ubiquitous phenomenon, there is little doubt that some species of jellyfish are flourishing in parts of the world. The causes of jellyfish blooms are equivocal, but have been related to overfishing, climate change, eutrophication, and the increasing amount of artificial marine structures that provide suitable habitat for the benthic stage of the life history.

The Second International Jellyfish Blooms Symposium was held on the Gold Coast, Queensland, Australia, in June 2007 and followed the highly successful inaugural symposium that was held in Alabama, USA in 2000. In the intervening years, some remarkable changes have occurred. Most notable has been the population explosion of the ‘giant jellyfish’ (>1-m diameter), *Nemopilema nomurai*, in East Asian waters. The ctenophore, *Mnemiopsis leidyi*, infamous for its invasion of the Black Sea,

has also recently appeared in northern European waters. Techniques for studying jellyfish have also advanced. In particular, molecular techniques are showing an increasing diversity of cryptic species of jellyfish and are being developed as tools to screen the hulls of ships and other infrastructure for invasive polyps. Acoustic techniques are being refined and are increasingly being used to quantify abundances, distributions, and movements of medusae. Natural tracers, such as stable isotopes and fatty acids more frequently are being used to complement traditional gut content analyses to examine trophic relationships. The polyp stage of the life history also recently has gained greater recognition because of its potential contribution to the development of blooms.

Thus, the 61 delegates from 17 nations who gathered in Australia had much to discuss! Professor Daniel Pauly, best known for his theory of ‘fishing down marine food webs’ opened the symposium by discussing how commercial fishing may contribute to jellyfish blooms and by encouraging jellyfish researchers to consider using applied fisheries techniques and to communicate better with ecosystem modelers. Professor Bill Hamner and Dr. Mike Dawson presented the plenary talk for the session on Diversity and discussed the phylogeography of jellyfish blooms. Dr. Jenny Purcell led the session on Trophic Ecology and encouraged researchers of jellyfish to start thinking on large, rather than local,

Participants of the Second International Jellyfish Blooms Symposium held at the Gold Coast, Queensland, Australia, 24–27 June 2007

scales. The final session on the Ecology of the Benthic Polyps was led by Professor Gerhard Jarms who emphasized that an understanding of the dynamics of jellyfish blooms required better knowledge of the demographics of the cryptic benthic polyps.

The papers presented in this volume are a subset of the 60+ talks and posters presented at the meeting. They provide a good representation of the diversity of issues discussed and hopefully will stimulate researchers worldwide to continue research into how and why jellyfish blooms occur.

The guest editors and conference organisers wish to thank the sponsors of the symposium, specifically the Ian Potter Foundation, CSIRO Land and Water, Griffith University, the Australian Rivers Institute (Griffith University), and James Cook University. The guest editors are also indebted to the numerous referees for their detailed and insightful reviews of manuscripts and, of course, to the contributing authors who stoically endured the numerous queries and requests of the guest editors.

Kylie Pitt (conference organiser and guest editor)
Jenny Purcell (guest editor)
Jamie Seymour (conference organiser)

Complete list of conference presentations

Oral presentations

Jellyfish in marine ecosystems. D. Pauly. University of British Columbia, Canada.

The phylogeography of jellyfish blooms. W. M. Hamner¹, M. N. Dawson². ¹University of California, Los Angeles, USA; ²University of California, Merced, USA.

Phylogeography of an invasive jellyfish indicates multiple independent invasions and intense founder effects. K. M. Bayha¹, T. Bolton², W. M. Graham^{1,3}. ¹Dauphin Island Sea Lab, USA; ²The Flinders University of South Australia, Australia; ³University of South Alabama, USA.

- Molecular analysis of the genus *Physalia* (Cnidaria: Siphonophora) in New Zealand. D. R. Pontin, R. H. Cruickshank. Lincoln University, New Zealand.
- Mitochondrial genomes of two jellyfishes, *Aurelia aurita* and *Chrysaora quinquecirrha*. D.-S. Hwang, J.-S. Lee. Hanyang University, South Korea.
- Patterns in pelagic cnidarian blooms in the North Atlantic. M. J. Gibbons¹, A. J. Richardson². ¹University of the Western Cape, Republic of South Africa; ²CSIRO Marine and Atmospheric Research and University of Queensland, Australia.
- Population dynamics and dispersal of *Pelagia noctiluca* in the Adriatic Sea. A. Malej¹, V. Malačič¹, A. Malej Jr², M. Malej², A. Ramšak¹, K. Stopar¹. ¹National Institute of Biology; ²University of Primorska, Slovenia.
- Jellyfish biodiversity in Taiwan, western North Pacific Ocean. W. T. Lo¹, P. H. Ho². ¹National Sun Yat-Sen University; ²National Taiwan Ocean University, Taiwan, Republic of China.
- Jellyfish appearances in Korean waters in 2006. W. D. Yoon, H. J. Gal, D. Lim, S. J. Chang. National Fisheries Research and Development Institute, Korea.
- Ecological niche conservatism in box-jellyfishes. B. Bentlage. University of Kansas, USA.
- An overview of the Rhopalophora (Cnidaria, Medusozoa) research in Indian waters. G. Kanagaraj¹, P. Samapthkumar¹, A. C. Morandini². ¹Annamalai University, India; ²Universidade Federal do Rio de Janeiro, Brazil.
- Reconstructing the invasion history of two independent introductions of the ctenophore *Mnemiopsis leidyi*. K. M. Bayha¹, G. R. Harbison², J. H. McDonald³, P. M. Gaffney⁴. ¹Dauphin Island Sea Lab, USA; ²Woods Hole Oceanographic Institute, USA; ³University of Delaware, USA.
- Phylogeny of Rhopalophora and the evolution of the paraphyletic Rhizostomae. I. Straehler-Pohl. University of Hamburg, Germany.
- Gelatinous zooplankton trophic ecology in the 21st Century: utilizing broad-scale and predictive approaches. J. E. Purcell. Western Washington University, USA.
- Estimation of trophic level of giant jellyfish, *Nemopilema nomurai*, using stable isotope ratio. M. Toyokawa. National Institute of Fisheries Research, Japan.
- Vertical migration of medusae in the open waters of south Adriatic Sea during 96 h sampling period (July 2003). D. Lučić¹, A. Benović¹, M. Morović², I. Onofri³. ¹University of Dubrovnik, Croatia; ²Institute of Oceanography and Fisheries, Croatia; ³University of Split, Croatia.
- Links between dissolved organic matter excretion by gelatinous zooplankton and bacterial metabolism. R. H. Condon¹, D. K. Steinberg¹, T. C. Bouvier², P. A. del Giorgio³. ¹Virginia Institute of Marine Science, USA; ²Université de Montpellier, France; ³Université du Québec à Montréal, Canada.
- The advection of scyphomedusae in the central Baltic Sea—Modelling, field data and possible consequences for trophic interactions. K. Barz¹, H.-J. Hirche¹, H.-H. Hinrichson². ¹Alfred Wegener Institute for Polar and Marine Research, Germany; ²Leibniz Institute of Marine Science, Germany.
- Ontogeny of association behaviour with jellyfish in jack mackerel *Trachurus japonicus* revealed by rearing experiment using *Aurelia aurita* and underwater observation in relation to *Nemopilema nomurai*. R. Masuda. Kyoto University, Japan.
- Bioenergetics in gelatinous zooplankton—the effect of prey species on energetic parameters. L. F. Møller, P. Thor, P. Tiselius. Göteborg University, Sweden.
- Development, biological regulation, and fate of *Mnemiopsis leidyi* blooms in the York River estuary, USA. R. H. Condon, D. K. Steinberg. Virginia Institute of Marine Science, USA.
- Jellyfish blooms that coincide with nutrient pulses can generate red tides. K. A. Pitt¹, M. J. Kingsford², D. Rissik³, K. Koop⁴. ¹Griffith University, Australia; ²James Cook University, Australia; ³New South Wales Department of Natural Resources, Australia; ⁴New South Wales Department of Environment and Climate Change, Australia.
- The polyps of the Scyphozoa and their impact on jellyfish blooms. G. Jarms. University of Hamburg, Germany.
- The life-cycle of the deep sea jellyfish *Aurelia octagonos* (Cnidaria: Scyphozoa: Coronatae). A. C. Morandini¹, S. N. Stampar², H. M. Pacca²,

- F. L. da Silveira², G. Jarms³. ¹Universidade Federal do Rio de Janeiro, Brazil; ²Universidade de São Paulo, Brazil; ³University of Hamburg, Germany.
- Morphological plasticity in polyps of *Aurelia* sp. in response to developmental temperature and food availability, and its subsequent effects on ephyrae: an experimental approach. L. M. Chiaverano¹, W. M. Graham^{1,2}. ¹University of South Alabama, USA; ²Dauphin Island Sea Lab, USA.
- Thermal decline and density of population as factors for inducing strobilation and budding in moon jellyfish, *Aurelia aurita*. N. L. Lim, E. Y. Koh, W. D. Yoon, D. Lim. National Fisheries Research and Development Institute, Korea.
- Seasonal changes in the density of *Aurelia aurita* polyps in the innermost part of Tokyo Bay. H. Ishii, K. Katsukoshi. Tokyo University of Marine Science and Technology, Japan.
- Effects of changing environmental conditions on polyp populations and production of ephyrae. S. Holst. University of Hamburg, Germany.
- Seasonal lunar spawning periodicity in offshore cubozoans. T. J. Carrette, J. Seymour. James Cook University, Australia.
- Visual ecology in two species of box jellyfish. A. Underwood, J. Seymour. James Cook University, Australia.
- Movement patterns in the Australian box jellyfish *Chironex fleckeri*: passive drifters or active locomotors? M. R. Gordon, R. Jones, J. E. Seymour. James Cook University, Australia.
- Behavioural responses of zooplankton to the presence of predatory jellyfish. E. F. Carr, K. A. Pitt. Griffith University, Australia.
- A comparison of the influence of symbiotic and non-symbiotic jellyfish on the nutrient cycling of coastal waterways. E. J. West, K. A. Pitt, D. T. Welsh. Griffith University, Australia.
- Life cycle of the jellyfish *Lychnorhiza lucerna* Haeckel, 1880 (Scyphozoa, Rhizostomeae). A. Schiariti^{1,2}, M. Kawahara³, S. Uye³, H. W. Mianzan^{1,2}. ¹Instituto Nacional de Investigación y Desarrollo Pesquero, Argentina; ²Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina; ³Hiroshima University, Japan.
- Real-time field measurements of *Aurelia aurita* using a Self-Contained Underwater Velocimetry Apparatus (SCUVA). K. Katija, J. O. Dabiri. California Institute of Technology, USA.
- The role of water column structure on jellyfish aggregation and reproduction in shallow coastal waters. W. M. Graham^{1,2}, J. E. Higgins III¹, K. Park^{1,2}. ¹Dauphin Island Sea Lab, USA; ²University of South Alabama, USA.
- New approach to the understanding of a marine ecosystem using acoustic survey of jellyfish aggregation. G. A. Colombo¹, A. Benović², M. Acha¹, D. Lučić², T. Makovec³, V. Onofri², A. Malej³, H. Mianzan¹. ¹Instituto Nacional de Investigación y Desarrollo Pesquero, Argentina; ²University of Dubrovnik, Croatia; ³National Institute of Biology, Slovenia.
- Mechanism and significance of *Aurelia* aggregations in Uwa Bay, Japan. N. Fujii, Y. Nanjo, J. Ooyama, H. Takeoka. Ehime University, Japan.
- Enhancement of jellyfish (*Rhopilema esculentum* Kishinouye, 1891) in Liaodong Bay, China. J. Dong, L. Jiang, K. Tan, C. Ye, P. Li, B. Wang. Liaoning Ocean and Fisheries Science Research Institute, China.
- Recent bloom of the giant jellyfish *Nemopilema nomurai* in the East Asian Marginal Seas: A brief summary. S. Uye. Hiroshima University, Japan.
- Mass appearance of the giant jellyfish, *Nemopilema nomurai*, along Japanese coasts and counter-measures. H. Iizumi¹, O. Kato¹, T. Watanabe². ¹Japan Sea National Fisheries Research Institute, Fisheries Research Agency, Japan; ²National Research Institute of Fisheries Engineering, Japan.
- Seasonal change of oocyte size of giant jellyfish, *Nemopilema nomurai*. M. Toyokawa¹, A. Shimizu¹, K. Sugimoto², K. Nishiuchi³, T. Yasuda⁴, N. Iguchi⁵. ¹National Research Institute of Fisheries Science, Fisheries Research Agency, Japan; ²Fukui Prefectural Fisheries Experimental Station, Japan; ³Seikai National Fisheries Research Institute, Fisheries Research Agency, Japan; ⁴Yasuda Fisheries Office, Japan; ⁵Japan Sea National Fisheries Research Institute, Fisheries Research Agency, Japan.
- Toxic components in the venom of the Lion's mane jellyfish *Cyanea* sp. H. Helmholz, C. Ruhnau, S. Lassen, R. Pepelnik, A. Prange. GKSS Research Centre, Germany.

Poster presentations

- Kinematical properties of the jellyfish *Aurelia* sp. T. Bajcar¹, V. Malačič², A. Malej², B. Širok¹. ¹University of Ljubljana, Slovenia; ²National Institute of Biology, Slovenia.
- Prospects of molecular systematics for Cubozoa. B. Bentlage¹, A. G. Collins², P. Cartwright¹. ¹University of Kansas, USA; ²NOAA's National Systematics Lab and National Museum for Natural History, Washington, DC, USA.
- Nematocysts and morphometrics of lion's mane jellyfishes, genus *Cyanea*, supporting the validity of *C. nozakii* and *C. annaskala* in Australian waters. R. H. Condon¹, M. D. Norman², K. M. Bayha³. ¹Virginia Institute of Marine Science, USA; ²Museum of Victoria, Australia; ³Dauphin Island Sea Lab, USA.
- Life cycle of a sea anemone parasite on *Aurelia* sp. from Veliko Jezero (Mljet, Croatia). I. D'Ambra, W. M. Graham. Dauphin Island Sea Lab and University of South Alabama, USA.
- Preliminary observations on the diet and feeding of *Chrysaora hysoscella* from Walvis Bay Lagoon, Namibia. B. Flynn, M. J. Gibbons. University of the Western Cape, Republic of South Africa.
- Seasonal variations in abundance, biomass and trophic role of *Aurelia aurita* s.l. medusae in a brackish water lake, Japan. C. H. Han, M. Kawahara, S. Uye. Hiroshima University, Japan.
- Complete mitochondrial genomes of two jellyfish, *Aurelia* sp. 1 (like *A. aurita*) and *Dactylometra quinquecirrha*. D.-S. Hwang¹, J.-S. Ki¹, Y. S. Kang², K. Shin³, J.-S. Lee¹. ¹Hanyang University, South Korea; ²National Fisheries Research and Development Institute, South Korea; ³Korea Ocean Research and Development Institute, South Korea.
- Biological characteristics of benthic polyp and planktonic juvenile stages of the giant jellyfish *Nemopilema nomurai*. M. Kawahara, S. Uye. Hiroshima University, Japan.
- Importance of jellyfish molecular analysis for global expansion and a parallel high throughput DNA-chip detection. J.-S. Ki, D.-S. Hwang, J.-S. Lee. Hanyang University, South Korea.
- Population studies of *Aurelia aurita* from Southampton Water and Horsea Lake, UK. C. H. Lucas. National Oceanography Centre Southampton, University of Southampton, U.K.
- Characterization of microsatellite markers for three species of invasive hydrozoans in the San Francisco Estuary, CA, USA. M. H. Meek, M. R. Baerwald, B. P. May. University of California, Davis, USA.
- The influence of ecological and physical factors on the settlement and viability of the moon jelly (Scyphozoa; *Aurelia* sp.) in the Northern Gulf of Mexico. M.-E. C. Miller, W. M. Graham. Dauphin Island Sea Lab and University of South Alabama, USA.
- Population structure of the scyphomedusae *Chrysaora lactea* and *Lychnorhiza lucerna* (Cnidaria: Scyphozoa: Discomedusae) in an estuarine area on southeastern Brazil. A. C. Morandini¹, S. N. Stampar², F. L. da Silveira². ¹Universidade Federal do Rio de Janeiro, Brazil; ²Universidade de São Paulo, Brazil.
- Scolionema* or *Gonionemus* (Cnidaria: Hydrozoa: Limnomedusae): morphology and life cycle helping to solve taxonomical problems. A. C. Morandini¹, S. N. Stampar², V. B. Tronolone². ¹Universidade Federal do Rio de Janeiro, Brazil; ²Universidade de São Paulo, Brazil.
- Stable isotopes emphasise the importance of large and emergent zooplankton to the diet of jellyfish. K. A. Pitt¹, A.-L. Clement^{1,2}, R. M. Connolly¹, D. Thibault-Botha². ¹Griffith University, Australia; ²Aix-Marseille Université, France.
- Recruitment to benthic phase of planula and growth of scyphozoan polyps (*Aurelia aurita*). K. Shin, W. J. Lee, D. H. Son. Korea Ocean Research and Development Institute, Korea.
- Effects of warming and low dissolved oxygen upon survival and asexual reproduction of scyphozoan polyps (*Aurelia aurita* s.l.). M. Takao, S. Uye. Hiroshima University, Japan.
- Interactions between fishes and invasive jellyfish in the upper San Francisco Estuary, USA. A. P. Wintzer, P. B. Moyle. University of California, Davis, USA.
- A new enzyme-assay for PLA2 activity in jellyfish venom based on phosphorus detection using HPLC-CC-ICP-MS. A. Zimmermann^{1,2}, H. Helmholz¹, D. Pröfrock¹, A. Prange¹. ¹GKSS Research Centre, Germany; ²University of Hamburg, Germany.