Cruise summary report RV Nereus 2018

Ship: RV Nereus, Call sign: SKTD
Type of ship: Research vessel

Cruise: 03.09.2018, 01.10.-31.12.2018, Jnr. 18/12748

Operating authority:
Tjärnö Marine Laboratory, Tjärnö, University of Gothenburg, Sweden

Owner: University of Gothenburg, Sweden

Name of master: Carl-Henrik Gustavsson

Scientist in charge: Ann Larsson

Principal investigators:
Ann Larsson
Rhian Waller
Wilhelm Fagerström
Julia Johnstone

Cruise dates and activities:
2018-12-03: Collection of 3 kg of *Lophelia pertusa* corals at the Tisler reef*
2018-12-14: Collection of 2 kg of *Lophelia pertusa* corals at the Tisler reef*

* All necessary permits were in place: the Ytre Hvaler National Park Board and the Norwegian Directorate for Nature Management permit for coral collections, 2010/107-432.3; 2018-18; the Norwegian Environment Agency, CITES export permit 18NO-034-EX; and the Swedish Board of Agriculture, CITES import permit Dnr: 4.10.18-13886/18 Nr: 52204-18.

Aim of the cruise

The aim of the cruise was to collect corals for studies of reproduction, embryo and larval development, and larval behaviour during different experimental conditions in the laboratory. Because only males were found in the December 3rd samples, a complementary cruise was needed. The spawning products from the corals were used in 4 different projects:

iAtlantic, Integrated Assessment of Atlantic Marine Ecosystems in Space and Time. H2020 project 2019-2024, PI Ann Larsson.

Cold water coral larval survivorship under environmental stressors: assessing anthropogenic impacts on vulnerable ecosystem engineers. MoRE-2020 project 2019, PI Rhian Waller.

Biophysical modelling of *Lophelia pertusa* larval dispersal in the Skagerrak. PhD-project 2018-2022, Vilhelm Fagerström.

Reproductive Ultrastructure of Deep Sea Corals in a Changing Climate. PhD-project 2017-2020, Julia Johnstone.

Summary of cruise results

When gametes were spawned, oocytes and sperm were collected separately for both descriptive morphology and for fertilization experiments. For descriptive morphology gametes were preserved for electron microscopy and will be examined under Scanning and Transmission Electron Microscopy (Fig 1).

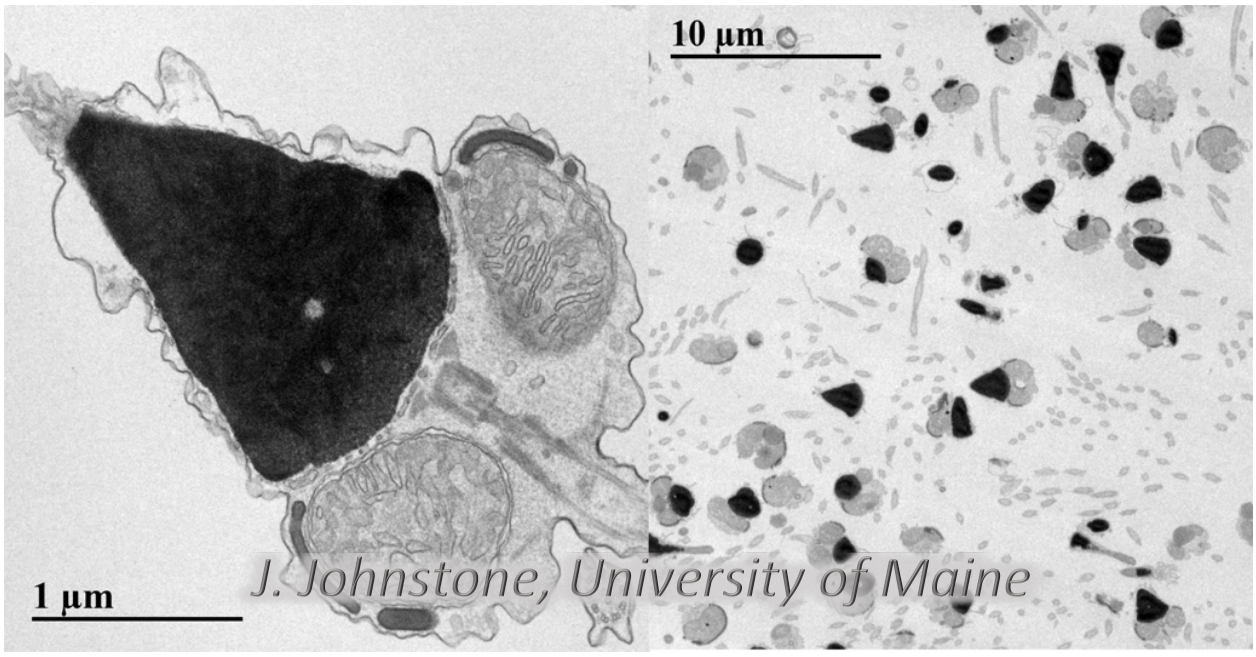

Figure 1. Transmission Electron Microscopy images of L. pertusa sperm. Image courtesy of J. Johnstone.

Maximum sperm concentration, motility, swimming speed and longevity were assessed at each spawning time between late February and early April. Oocytes were also assessed for longevity. Fertilization experiments were then performed at various sperm and oocyte concentrations and over 72hr duration, to examine ideal concentrations and timing for maximum fertilization. These experiments were repeated at each time point we obtained both oocytes and sperm. Fertilization experiments were also repeated at 4 different temperatures (4°C, 8°C, 12°C and 16°C). Initial results show *L. pertusa* to be able to fertilize at low concentrations and over long time periods, no doubt enabling the success of this widespread species.

Furthermore, the embryo and larvae were cultured at a range of temperature and salinities to assess the effects of climate change. *Lophelia pertusa* is also is found in a span of latitudes in the world's oceans. Hence although the adult form is largely restricted to oceanic salinities and temperatures of 4–12 °C, the vertically migrating larvae may encounter waters of much wider salinity and temperature ranges.

We investigated the role of salinity and temperature on *L. pertusa* larval properties with focus on traits affecting dispersal potential. Temperature effects on the embryo and larva development rates were studied together with survival rates and longevity. Temperature induced differences in larval swimming speed and ontogenetic vertical distribution pattern were also documented. Survival of ciliated embryo in various salinities were tested and results show that larvae survive for months in 23 psu which was the lowest salinity tested. Further

preliminary results indicate that in 4°C embryo development is highly irregular and extremely slow. The development rate in 12°C is about twice as fast as in the ambient 8°C. The appearance of cilia needed for swimming and developed cnidocysts needed for larval attachment (Fig 2) comes much earlier with increasing temperature. Larval swimming speed is approximately 1.5 times faster in 12°C compared to in 8°C. Ciliated embryo moved to 16°C continued to develop normally and the larvae survived for months. First signs of bottom probing also appear earlier with increasing temperature.

In conclusion larvae of *L. pertusa* can tolerate a wider range of salinities and temperatures than the adult form. Furthermore, with the increasingly faster development rates with temperature, larvae mature faster and will in average disperse shorter differences. As a result, increasing temperatures due to climate change may decrease connectivity among populations. This study also highlights the importance of taking into account the ambient water temperatures larvae are transported in when modelling connectivity among populations using biophysical dispersal models.

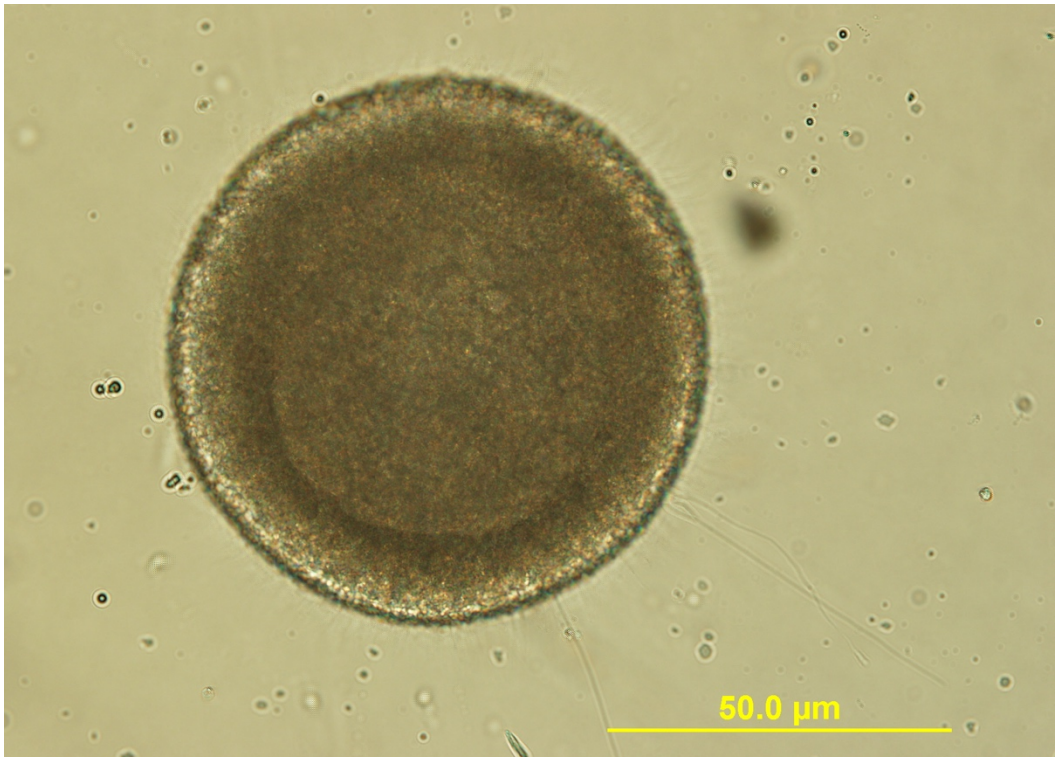

Figure 2. Light Microscopy image of L. pertusa larva with fired cnidocysts indicating readiness to attach to a substrate. Image courtesy of A. Larsson.

Another factor crucial for biophysical dispersal models is to know where in the water column larvae are transported. Through previous studies of larvae in the laboratory, we have discovered that larval swimming is directed upwards during the first month, possibly indicating that larvae are transported in faster near-surface currents during part of their dispersal time. We have now extended our investigations to study if larvae are able to maintain an upward swimming direction also in turbulent water. Using a grid stirred turbulence tank in combination with Particle Image Velocimetry (Fig 3) simultaneous measurements of turbulence, instantaneous flow fields and larval swimming speeds were acquired. Analysis is still ongoing but preliminary results indicate larvae can direct their

swimming in energy dissipation rates of at least 10^{-6} m^2 s^{-3} although with reduced effective upward swimming speed. The final outcome of our experiments will help improving the predictions of *L. pertusa* larval dispersal from oceanographic modelling.

Figure 3. Test setup of turbulence tank, camera and laser for simultaneous recordings of larval swimming and flow velocity vectors using Particle Image Velocimetry. Image courtesy of A. Larsson.

Results will be published in peer reviewed scientific articles.

Tjärnö 2019-09-18
Ann Larsson