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NACA to host the International *Artemia* Aquaculture Consortium

Artemia remains a critical feed source for larval fish and crustaceans. As the global aquaculture industry continues to expand, so does demand for *Artemia* cysts, which underpin the hatchery production phase for around 10 million tonnes of aquaculture.

Around 90 percent of current *Artemia* cysts are naturally produced and harvested from inland salt lakes. This is a risk to a significant portion of the aquaculture industry. There is a need to assure the sustainable supply of *Artemia* cysts to support hatchery production, from both wild and farmed sources.

A new international and interdisciplinary approach is needed to tackle these *Artemia* issues and opportunities, as happened following the breakthrough in *Artemia* use in aquaculture following the 1976 FAO Kyoto conference.

In November 2019, a meeting of *Artemia* experts in Kuala Lumpur conceived of establishing the International Artemia Aquaculture Consortium, a network of scientists and institutions that would collaborate in exploring opportunities such as the conservation of *Artemia* biodiversity, development of science-based protocols for sustainable harvesting of wild sources, strain selection and selective breeding, and many more. A provisional Steering Committee was established, and a provisional website established courtesy of the Institute of Marine Biotechnology, University Malaysia Terengganu.

On 20 April Prof. Patrick Sorgeloos visited the NACA Secretariat to discuss cooperation, and it was agreed that NACA would host the consortium, playing a coordinating role and establishing a permanent website presence. Dr Huang Jie, Director General of NACA, indicated that the Secretariat was pleased to be involved in the initiative, which offers many exciting research opportunities of global significance.

NACA's first contribution as host to the consortium was to assist in convening two regional webinars on The History of *Artemia* Activities in Africa (4 May) and on Management of *Artemia* Resources of the Great Salt Lake (5 May, see meeting report this issue). These events led on from last year's NACA Webinar on Status of the Use of *Artemia* Cysts in Fish/Crustacean Hatcheries Around the World (2 September 2021) and the consortium's SDG-aligned *Artemia* Aquaculture Workshop (22 September 2021), which was held in conjunction with the Global Conference on Aquaculture Millennium +20 (the report of the workshop is available in the January issue).

Key conclusions and recommendations from these workshops were presented at the recent FAO Sub-committee on Aquaculture Meeting, held virtually from 24-27 May 2022, where they attracted favourable comments, the report will be considered by the FAO Committee on Fisheries in September.

The new consortium website will be published on https://artemia.info within a few weeks. An announcement will be made on the NACA website and in this newsletter when it is available.

Wenzhou virus 8 (WZV8) diagnosis by unique inclusions in shrimp hepatopancreatic E-cells and a molecular detection method

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To assist shrimp pathologists worldwide we are providing an advisory containing photomicrographs of unique basophilic inclusions that are produced by Wenzhou shrimp virus 8 (WZV8) (Li et al. 2015) that was discovered in 2015 by wide screening of marine animals for RNA viruses using high throughput sequencing (GenBank record KX883984.1). The advisory provides people with the tools to recognize WZV8/PvPV which we refer to as WZV8, in H&E stained slides. We also offer a free RT-PCR method and a free positive control plasmid to anyone who asks for it. We hope that this will allow a global effort to find out the range of this virus and get some idea of its impact.

The advisory is available for download from:

https://enaca.org/?id=1213

A more recent publication from China (Liu et al. 2021) also gives the full sequence under GenBank record OK662577 that is highly similar to WZV8 (97% coverage and 95.4% sequence identity) but under the newly proposed name *Penaeus vannamei* picornavirus (PvPV). Although that paper contained no histological analysis, it did include an electron micrograph of a cytoplasmic

viral inclusion within a vacuole of an unspecified hepatopancreatic epithelial cell type (Liu et al., 2021).

Using the sequence of KX883984.1, we designed PCR primers and in situ hybridization probes for detection of WZV8. Subsequent ISH assays with shrimp RT-PCR positive for WZV8 samples allowed us to identify unique inclusions described herein as linked to WZV8 in hematoxylin and eosin (H&E) stained tissues. In some of the specimens positive for WZV8 with ISH assays, positive ISH reactions were also seen in normal nuclei in the central region of the HP and in the subcuticular epithelium and underlying connective tissue (especially in the stomach) indicating that these tissues are of no use for histological diagnosis of WZV8 infection because of their normal appearance with H&E staining.

Going back over our previous histological reports and archived slides, we have found the unique WZV8 inclusions in E-cells of normal shrimp samples from several shrimp farming countries in Austral-Asia since at least 2008. More recently we have obtained samples of *P. vannamei* from the Americas that also show these inclusions. We have noticed these inclusions for many years as unique basophilic, cytoplasmic inclusions of unknown origin that occur mostly in E-cells of the tubule epithelia of the hepatopancreas (HP) of both diseased and normal, cultivated *P. monodon* and *P. vannamei*. In diseased samples, mortality was ascribed to bacteria or known lethal viruses. As a result, the additional presence of these inclusions of unknown origin and their relatively common presence also in shrimp with no signs of disease resulted in their relative neglect while efforts were focused on more urgent problems.

We urge shrimp pathologists to review their records and archived and current specimens for the presence of the unique WZV8 E-cell inclusions described herein. Hopefully, this will result in data that will provide a global view of the current prevalence and impact of WZV8-like infections.

Report on the Webinar on Management of *Artemia* Resources of the Great Salt Lake 5 May 2022

International Artemia Aquaculture Consortium

The International Artemia Aquaculture Consortium (IAAC) hosted a webinar on Management of the *Artemia* Resources of the Great Salt Lake, 5 May 2022, at 14:00 UTC. The purpose of the webinar was to familiarise participants with recent international developments in *Artemia* research cooperation, and to examine the Great Salt Lake as a case study in successful management of *Artemia* resources in a multi-stakeholder environment.

Summary of the webinar

Welcome and aims of the webinar

Patrick Sorgeloos (Artemia Reference Center, Belgium) gave an overview of the International Artemia Aquaculture Consortium (IAAC). The consortium is an informal network of research institutions and *Artemia* producers that have interests to consolidate and expand the sustainable use of *Artemia* in aquaculture. The present workshop had been organized with reference to a recommendation made at the SDG-aligned *Artemia* Aquaculture Workshop, held 22 September 2021 in association with the Global Conference on Aquaculture Millennium +20, to “Develop science-based protocols to assure sustainable harvesting of wild *Artemia* sources, especially in central Asia”.

History of sustainable harvest management on Great Salt Lake

Thomas Bosteels (Great Salt Lake Brine Shrimp Cooperative, Inc.) gave a presentation on the evolution of *Artemia* harvest management on the Great Salt Lake. By the early 90’s harvesting pressure had increased in the absence of formal state programs to manage, protect and researcher the resource, or to regulate the harvest.

Concerned about sustainability, industry approached the (then) Utah Division of Wildlife Resources (UDWR) regarding management of the *Artemia* resource, and agreed to pay increased fees in order to fund research on the lake’s ecology. As a result, the department:

- Established the Great Salt Lake Ecosystem Program to manage the *Artemia* resource and ecosystem.
- Established a Technical Advisory Group to review scientific data.
- Leveraged the research by entering into joint research programs with the United States Geological Survey and several universities.

Through these arrangements, the support of industry and the research data generated, the UDWR was able to determine the necessary escapement stock of *Artemia* cysts to assure optimal populations and establish a sustainable management model. After 25 years of implementation and sampling to verify recruitment, the optimal escapement stock has not substantially deviated from the original 21 cysts per liter implemented in 1997. Variability of harvest has decreased, while average dry weight equivalent harvest has increased, indicating successful management. Further study of the ecosystem and refinement of the model continues.

Initial policy efforts to protect Great Salt Lake

Timothy Hawkes (Utah State Representative, USA) gave a presentation on initial education and policy efforts to protect the GSL. Until around 2010 the GSL had not received much attention from policy makers. After peaking in the 80’s, water levels in the GSL fell significantly due to both a dry cycle and increased human utilization. In response to stakeholders concerns a

GSL Advisory Council (GSLAC) was established, with a broad membership including counties, state agencies, NGOs, companies interested in mineral extraction and *Artemia*. The GSLAC provided an effective forum for vetting issues, conducting research and raising awareness of issues such as the lake's health, economic value, costs of declining water levels and strategies for water management and other issues.

In 2018 a full time GSL Coordinator was hired, enabling a significant boost in reports and communications. In 2019 the GSL Integrated Management model was published concerning the water supply and ecosystem, which indicated that modest conservation of water would dramatically increase the chances that over time the lake elevation would stay within healthy and sustainable levels.

Another key report by the GSLAC concerned the costs and environmental consequences of declining water levels, such as dust-related impacts and local climate/rainfall effects, also drawing on examples from other terminal lakes from around the world that have experienced problems, such as the Aral Sea.

In 2019/2020 a brainstorming exercise gathered public input on strategies to improve water management, the most promising of which are beginning to be implemented. Recent studies have also examined the impacts of conservation measures, which are generally positive in that they increase water availability, and on measures to increase re-use of water, for example by treating sewerage treatment water (about 25% of usage) to a higher standard.

Managing salinity and nutrients on Great Salt Lake, a cooperative approach involving multiple stakeholders

Thomas Bosteels gave a presentation on a multi-stakeholder collaborative approach to managing salinity and nutrients in the GSL, which are two of the primary drivers of the *Artemia* population. The "safe" salinity for optimal production lies between 100-180 g/L. Lower salinity levels result in increased predation upon *Artemia* and increased prevalence of unfavourable phytoplankton assemblages, while higher salinity begins to impact *Artemia* survival, maturation and reproduction. Annual salinity swings can be as high as 20 g/L, narrowing the target salinity for management to 120-160 g/L.

The GSL is bisected by a man-made causeway. All drainage into the lake occurs in the less saline south arm, which has a strong salinity differential with the saturated north arm. Originally, two culverts allowed bi-directional flow between the north and south arms, but after the culverts failed, a new breach was constructed in 2016 to re-establish flows. The new breach was fitted with an adaptive management berm that could help regulate salinity by differentially restricting density driven heavy brine north-to-south flow, and density/hydraulic head driven lower salinity south-to-north flow.

Salinity management is overseen by a multi-stakeholder Salinity Advisory Committee (SAC). The SAC has developed standard operating procedures for GSL water density measurement and salinity calculation, developed a salinity matrix illustrating the benefits and impacts of different salinity levels on biota and industry, recommends a suitable salinity range (120-160 g/L) to maximise benefits, and reviews data and models to advise on berm geometry modification to maintain salinity within the recommended range.

The United States Geological Survey (USGS) has studied nutrient inflows and cycling in the GSL since the mid 90's. Inflows represent < 10% of dissolved nitrogen in the southern arm of the lake, with a high level of nutrient cycling between trophic levels and temporary nutrient peaks characteristic of the natural hypersaline ecosystem. The GSL is principally nitrogen limited, with some co-limitation of phosphorus, and has high capacity for additional nutrient enrichment, which provides protection of *Artemia* harvest against a reduction in lake volume. The lake volume is not the primary driver of the *Artemia* volume.

In 2011 the Utah Division of Water Quality (DWQ) created the multi-stakeholder Nutrient Core Advisory Team and Nutrient Technical Review Team to guide the development of management criteria based on nutrient concentration and ecological responses in Utah streams. The diversity of interests on the teams provides a balanced approach to development of nutrient criteria that allow beneficial uses of Utah streams to be protected while considering the needs of all aquatic ecosystems including the GSL. As a result, the DWQ has implemented solutions to maintain nutrient inflow into the GSL while protecting beneficial uses in less saline aquatic ecosystems.

More mature law and policy efforts to protect water supply enhanced stakeholder engagement: What does the future hold?

Timothy Hawkes presented on the maturation of the legal and policy response to protection of the GSL, with the legislature becoming more engaged in recent years. In 2019 a resolution was passed to address declining water levels of the GSL, mandating that state agencies should consult stakeholders to gather input on ensuring adequate water flows to the GSL and its wetlands. Sixteen opportunities and 60 recommendations emerged from this process.

In 2020 legislation was passed to enable water banking, and split season leasing, facilitating water sharing between traditional consumptive uses and the environment, promoting efficient utilisation using free market forces.

In 2022 the Governor of Utah announced the budget from the shore of the GSL to draw media attention to the lake. The House Speaker hosted a summit for policy makers and elected officials in January to draw media attention to the GSL. These have helped drive a significant policy response, with six new bills passed directly concerning GSL resource management, and four more with indirect implications for the GSL:

- The *Great Salt Lake Watershed Enhancement Bill* establishes the legal framework for a financial trust to protect the GSL and its water supply. The bill deposits US$40 million into the trust, of which US$30 million is for water and US$10 million for connected habitats.

- The *Great Salt Lake Amendments Bill* calls on the Utah Division of Water Rsources to develop and implement an integrated water assessment for the GSL, appropriating US$5 million to fund the assessment.

- The *Sovereign Lands Management Account Bill* restricts funds derived from the GSL to GSL and other sovereign lands owned by the State of Utah. It creates a new restricted account for royalties derived from

lithium or other newly extracted minerals that can only be used to protect the lake's water supply.

- The *Instream Flow Amendments Bill* allows the Utah Department of Forestry, Fire and State lands to acquire and hod instream flow rights. It explicitly recognises the ability of the state and other entities to acquire and hold water rights to benefit the GSL and reduces legal obstacles for such water rights.

Closing remarks

Closing remarks were given by Mike Rust (National Oceanic and Atmospheric Administration, USA). He noted that while considerable research had been invested in microparticulate substitutes for *Artemia*, they had only been partially successful. *Artemia* remained a strategic resource for aquaculture.

The workshop had shown how a vision could become a reality, in terms of the industry pursuing a vision of long-term sustainability and committing financial resources to support it, with scientists providing tools for sustainable management and policy makers helping to establish a framework for governance of the resource. Management had turned out to be considerably more involved than just regulation of harvesting. It was significant that while management started with good harvest management, to accomplish the vision for long term sustainability, management of other ecosystem processes became just as important, such as salinity, flows and nutrient management, overwintering, genetics and ecosystem interactions and services, and engineering of berms. Scientific input remained an ongoing need for resiliency, to guide adaptive management, with the western US in a persistent long-term drought condition.

Coordination of stakeholders requires an effective governance structure and the GSL provided a good example of industry and government partnership. Initially driven by industry, government partnership had provided a place and structure to allow industry, science, and other stakeholders to interact and has added financial and scientific resources to that effort. Further policy and then legal frameworks were then justified to introduced tools such as water banking and others for sustainable ecosystem-based management of the GSL.

In addition to providing around one third of the *Artemia* used by the world's aquaculture, the GSL provided a great example of a collaborative, ecosystem-based, sustainable management of a strategic resource for the long term.

Participants were advised that the presentations and report from the webinar (this document) would be made available on the IAAC website in due course. The report and its conclusions would be tabled at the forthcoming virtual meeting of the FAO Sub-Committee on Aquaculture, which would be held from 24-27 May 2022.

Acknowledgements

The International Artemia Aquaculture Consortium would like to thank the speakers, Patrick Sorgeloos, Thomas Bosteels, Timothy Hawkes, Mike Rust, and moderator Simon Wilkinson for their time and contribution to the webinar.

Twentieth Meeting of the Asia Regional Advisory Group on Aquatic Animal Health

This report summaries the proceedings of the 20th meeting of the Regional Advisory Group on Aquatic Animal Health, held 4-5 November 2021. The role of the group is to review trends in disease and emerging threats in the region, identify developments in global disease issues and standards, to evaluate the Quarterly Aquatic Animal Disease Reporting Program and to provide guidance on regional strategies to improve aquatic animal health management. The meeting discussed:

- Progress on NACA's Asia Regional Aquatic Animal Health Program.
- Updates from the OIE Aquatic Animal Health Standards Commission.
- Aquaculture biosecurity.
- Progressive Management Pathway for Improving Aquaculture Biosecurity activities relevant to Asia.
- A systematic approach for quantifying biosecurity measures in aquaculture.
- Aquatic Animal Health Strategy.
- Updates on OI Regional Collaboration Framework on Aquatic Animal Health.
- Updates on QAAD Reporting and Disease List.

Members of the Advisory Group include invited aquatic animal disease experts in the region, representatives of the World Animal Health Organisation (OIE) and the Food and Agricultural Organization of the United Nations (FAO), collaborating regional organisations such as SEAFDEC Aquaculture Department (SEAFDEC AQD) and OIE-Regional Representation in Asia and the Pacific (OIE-RRAP), and the private sector.

The report is available for download from the NACA website at:

https://enaca.org/?id=1209

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