The Lobster NEWSLETTER

ICWL
12th International Conference and Workshop
Lobster Biology and Management

Fremantle, Western Australia | 22-27 October 2023

(photo: Lauren Dunkley)

ICWL Returns to its Roots!

From: Peter Rogers and Nick Caputi

About 200 delegates from 18 countries attended the Esplanade Hotel, Fremantle, Western Australia (WA) during 22-27 October 2023. The event organisers received 260 abstracts, organised the delivery of over 157 oral and 20 poster presentations and facilitated shared learnings from leading lobster and crab researchers and managers across many of the world's fisheries. A special feature of presentations included involvement of student researchers and keynote addresses each day by selected guest speakers.

Attendees of the 1st International Lobster Conference in Western Australia in 1977. ICWL founders Bruce Phillips and Stan Cobb stand first and second from left, respectively. Bill Herrnkind stands sixth from the left.

This conference was the 12th in a series of International Conference and Workshop on Lobsters (ICWL) which started in 1977 in Western Australia. This provided an opportunity to remember and recognize three pioneers of the conference by naming sessions in their honour:

- Stan Cobb Life Cycles Session
- Bill Herrnkind Behavioural Session
- Bruce Phillips Recruitment Session.

A brief summary of their significant contribution to Lobster Science was given by Rick Wahle and Mark Butler IV for Stan and Bill, and Bruce also gave a summary of his contribution.

Financial support for the conference was assisted through sponsorship notably by Western Rock Lobster (WRL), the Fisheries Research and Development Corporation (FRDC) and the Department of Primary Industries and Regional Development (DPIRD WA). Of special note included travel sponsorship of invited speakers by OECD Co-operative Research Programme (CRP): Sustainable Agricultural and Food Systems for the Ecosystem-based Fisheries Management (EBFM) workshop on the 22-23 October. There was also support provided for students, early career scientists and scientists from developing countries by the Jock Clough Marine Foundation, Western Australian Marine Science Institution, Paul Kanciruk Student Travel Award, and DPIRD. Other sponsors included WA Fishing Industry Council, Marine Stewardship Council, Dongara Marine, and Institute of Marine and Antarctic Studies at University of Tasmania.

An active social events program helped facilitate an atmosphere of fellowship, information exchange, renewal of long-term relationships between longer-term delegates from past conferences and new networking and co-operative research opportunities. This started with delegates having an open invitation to attend Fremantle's Blessing of the Fleet, followed with registration and arrival barbecue and welcome by Ms Heather Brayford, Director General of DPIRD. Other events including a poster evening, conference dinner and end of conference sundowner, were held.

The attendees were treated to a Welcome to Country ceremony by Barry Winmar which was followed by the official opening of the conference by Professor Peter Klinken, WA's Chief Scientist. He reminded delegates of the importance of science, the need for greater collaboration across all professions, industries, governments and institutions. The huge

technical capabilities in computerisation, artificial intelligence, data manipulation and new science development that is unparalleled in the world's history. The real threats of climate change both in terms of rising temperatures and increasing ocean acidity and the impact on fisheries coupled with the need for an effective systems approach to address the uncertainties associated with managing the future for fisheries and ocean uses setting the scene for Ecosystem-Based Fisheries Management (EBFM).

The presentations provided many examples throughout the conference of EBFM approaches across lobster and crab fisheries across the world. Some more successful than others, complicated by the issues of scale, jurisdictional governance issues in the management of individual stocks and institutional and funding arrangements to facilitate the research needed. EBFM as a systems approach was increasingly being followed and evidenced by so much of the science and case studies presented.

The involvement of indigenous knowledge and commercial and recreational fishers in research and management was themed in a number of papers. Also covered for different lobster and crab resources was the importance for both research and management needs of fishery-independent survey indexes of breeding stock levels and recruitment, and ocean modelling used to facilitate understanding over time and space in the movement of larvae.

Other fisheries science themes of considerable importance included habitat and environment, diseases and parasites, behaviour, life cycle and recruitment. Fisheries science linked to stock assessments was a major theme reporting on new developments in data collection using imagery, fishery-independent surveys, best practice stock assessment methods, tagging approaches and interpretive risks arising from climate change where relevant.
Presenters have the option to provide fully authored papers which will be peer-reviewed and published in a special edition of *Fisheries Research* for all to access. The summaries below provide a taste of topics and issues covered.

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Thanks to the staff of Western Australia's Department of Primary Industries and Regional Development who co-hosted and contributed to the conference. (photo: Lauren Dunkley)

12th ICWL SESSION SUMMARIES

ICWL Workshop: Ecosystem-based Fishery Management Workshop Overview

Chairs: Nick Caputi, Rick Fletcher and Michael Fogarty

The theme of the conference was 'ecosystem-based fisheries management (EBFM)'. EBFM, which is also referred to as ecological sustainable development (ESD) or triple bottom line assessment, as the approach covers the ecological effects of fishing (including effects on protected species), economic and social issues, as well as the sustainability of the targeted lobster and crab stocks. While EBFM was the overall theme of the 5-day conference, a special EBFM lobster workshop supported by the Organization for Economic Co-operation and Development Co-operative Research Programme (OECD CRP) occurred over the first two days, 23-24 October 2023.

There were two keynote and two invited speakers that presented in the EBFM workshop:

- **Prof. Gretta Pecl** spoke on 'Fisheries in a warming world and changing ocean, what's in store and what's needed to ensure a thriving future.'
- **Dr. Rick Fletcher** spoke on 'The role of the western rock lobster fishery in the successful development of Ecosystem-Based Fishery Management (EBFM) in Western Australia'.
- **Emeritus Prof. Gordon Kruse** spoke on 'Ecosystem-based fisheries management of crab fisheries in the Bering Sea and Aleutian Islands'.
- **Emeritus Prof. Ehud Spanier** spoke on 'Marine Protected Areas (MPAs) – a review of their potential effects on lobster ecology & management'.

There were 36 presentations during the EBFM workshop with six of the presenters supported by the OECD CRP. The presentations covered the breadth of EBFM issues such as ecosystem effects, social, economic, environmental impacts, bycatch, governance issues as well as effects on the targeted lobster and crab stocks.

At the end of the EBFM workshop Dr. Rick Fletcher and Dr. Michael Fogarty provided a summary of some of the key points from the presentations. Some of the major outcomes and conclusion in terms of policy relevance were:

- Importance of the research and management of lobster and crab species taking a 'whole of resource' approach rather than focusing on a particular fishery or sector. This can be particularly

important when resources cross state and/or international boundaries.

- The explicit recognition and inclusion of economic and social objectives in the fisheries management harvest strategies.
- The importance of proper governance structures in the management of fisheries and robust compliance and education programmes to support the management of fisheries was raised as a significant issue in some fisheries.
- A number of presentations highlighted the importance of minimising the interactions of the fisheries with protected species such whales migrating through the area of fishing. These interactions are particularly important when dealing with populations that are threatened and endangered.
- Several presentations highlighted the importance of having long-term fishery-independent surveys in the assessment of lobster and crab stocks rather than relying on commercial catch rates, which can be biased as a result of changes in fishing efficiency and changes in fishers' targeting practices.
- The recovery of lost fishing gear was highlighted as it can have a significant impact on stocks and the marine ecosystem.
- The recognition of the key spatial processes was highlighted in several presentations that looked at connectivity between areas through larval dispersal and migration. These studies then have policy implications in spatial management of fisheries and the formation of marine protected areas.
- The importance of incorporating traditional knowledge systems into western science assessment of fishery stocks and in the management of these stocks was an important highlight. Humans, as an integral part of the ecosystem, is a central theme in EBFM. The traditions of indigenous peoples have long embraced this concept and serve as an important guide in fully implementing this perspective in EBFM.

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ICWL venue at the Esplanade Hotel in Fremantle. (photo: K. Ley Cooper)

Lobster boats welcome celebrants to the Blessing of the Fleet in Fremantle, 22 October 2023. (photo: R. Wahle)

ICWL Session: EBFM Workshop - Climate Change & Environmental Effects

Chairs: Jim Penn and Tim Langlois

On day-1 of the ICWL a keynote address was given by **Gretta Pecl** on "Fisheries in a warming world and changing ocean, what's in store and what's needed to ensure a thriving future". Gretta provided the background and evidence associated with climate change predictions, the significance of this threat and urgency for the fisheries world, including governments, managers, researchers and industries to understand and adapt, to deal with consequences and uncertainties. This included finding new solutions. The matter of principal concern was recent evidence of ocean temperatures rising faster than predicted and the priority behind closely monitoring and urgently responding to this threat as the trend is expected to continue. Some key issues from the 10 presentations on environmental effects and climate change, which covered fisheries in Western Australia, USA, South Africa, UK and Spain, included:

- Ensuring that impacts of climate change on the fishery resource are assessed and addressed in the management of fisheries. If the keynote address by Gretta Pecl highlighted the serious issues facing the marine ecosystem as a result of climate change, then on day-2 the keynote address by **Gordon Kruse** provided practical examples of some of the climate changes observed in the Alaskan crab fisheries.

- A key policy implication of long-term trends in climate change means that we cannot assume stationarity in the biological parameters (such as growth, mortality, maturity) that we use in stock assessment modelling and hence in the management of fisheries.

- In some cases, regime shifts can occur which can result in major shifts in the abundance and spatial distribution of stocks and hence need to be taken into account in the management of fisheries.

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ICWL Session: EBFM Workshop - Ecosystem Effects of Fishing

Chairs: Jason How and Alison MacDiarmid

Effects of fishing was a key component of the conference's Ecosystem-based Fishery Management theme. There were a number of presentations which spoke to the effects of fishing on various components of the ecosystem. These were primarily focused around endangered, threatened and protected species interactions, the impacts of ghost gear from fishing activities, connections across disciplines, spatial gradients and timelines. Examples came from both the Caribbean, Atlantic and Indian Oceans highlighting the global nature of these issues.

Presentations on mitigating protected species interactions focused on "traditional" management arrangements, such as target fishery stock levels and season start dates (**Jason How**), and how differing management arrangements could be compared through a decision-support tool (**Burton Shank**) to reduce large whale entanglements. Practical application of some of these measures was presented from work

conducted by the Prince Edward Island Fishermen's Association, which included understanding current gear configuration, whale-safe gear implementation and retrieval of ghost gear (**Melanie Giffin**).

Ghost gear or abandoned, lost, and discarded fishing gear (ALDFG) and associated plastics lost to the ocean was another key theme in the effects of fishing component. Examples came from large scale commercial fisheries such as the West Coast Rock Lobster Managed Fishery (Australia; **Katrina Bornt**), as well as smaller community-based fisheries in the Gulf of Mexico and the Mexican Caribbean (**Kim Ley Cooper**). These projects examined means by which ALDFG could be reduced, with practical examples of ghost gear retrieval being presented from Canada, using electronic techniques to identify and retrieve gear while minimising ecological impacts (**Maryse Cousineau**).

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ICWL Session: **Habitat and Environmental Effects**

Chair: Ehud Spanier

The session on *Habitat and Environmental Effects* included the following oral presentations:

Martial Laurans (Institut Français de Recherche pour l'Exploitation de la Mer) spoke on "Crayfish (*Palinurus elephas*) in Atlantic French waters: towards the recolonization of its historical distribution area". The annual landing of this species in Cornwall and Brittany has increased from 20 tons to 125 tons during 2017-2022. This steady increase is related to the management guidelines established in 2007. To ensure sustainable exploitation, the knowledge on the biology and ecology of this species should be improved. Acoustic tags have been used to tag 120 individuals (50 in Brittany and 90 in Cornwall) in the framework of FISH INTEL project. A local network has been established for the two sites with 4 to 8 receptors. Daily and winter behavior as well as depth data were recorded for more than one year for 90% of tagged lobsters. The results seem to confirm those obtained previously (during the LLR and PNMI projects). Unlike juveniles, mature individuals, and especially males, showed sedentary behaviors. Most activities happened during the night. The results were widely shared with fishermen to integrate the knowledge to adapt, improve or develop new management tools.

Michel Brooker (University of WA Oceans Institute, Australia) presented a lecture entitled: "Chemotaxis is important for fine scale habitat selection of early juvenile *Panulirus cygnus*". The ability of early juvenile western rock lobster to select and settle onto suitable habitats is critical for the recruitment of this commercially important species. The active habitat selection of early juvenile western rock lobsters was tested using only chemotaxis in scent-based Y-maze bioassay. Individuals were presented with several different natural scent stimuli. Seagrass habitats were chosen significantly more often by the juvenile lobsters in the broad habitat scale trials over bare sand and turf habitats. At a finer scale, lobsters showed a mixed response, but tended to choose the canopy-forming seagrass species, *Amphibolis* and *Posidonia australis* significantly more often than

the other scents provided. The findings suggest the importance of seagrass habitats to early juvenile western rock lobsters and the potential impacts that habitat change may have on the successful recruitment of this commercially important species.

Mark Butler (Florida International University, USA) presented a paper entitled: "If management of the fishery for Caribbean Spiny Lobster were based on ecology". He discussed the "management" of fisheries for the Caribbean Spiny Lobster (Panulirus argus) which is spanning over 240,000 km^2 of seafloor and more than 30 countries, is founded on closed-population models. Robust fisheries for the species remain, as a result of their ecological pedigree – one more in common with cockroaches than fish. Highly fecund with widely dispersing larvae, the fast-growing juveniles and adults are mobile, resilient to environmental change, and indiscriminate in their diet and shelter use. So what might the management of fisheries for *P. argus* resemble if it logically reflected their ecology while ensuring the long-term sustainability of the resource and its fishery? It would begin with the institution of cooperative management among countries that ignored geopolitical borders, as do lobster larvae. It would include an integrated, but regionally distinct system of fishery quotas, nursery habitat protections, and "larval credits" in recognition of the species' Caribbean-wide metapopulation dynamics. It would marry effectively enforced no-take marine reserves spanning multiple habitats that link life stages with harvest size slot-limits to maximize spawning stock production. And it would promulgate the use of fishing gear that limited negative impacts on benthic communities and minimized bycatch.

The presentation by **Katie Cresswell** (University of Tasmania, Australia) was entitled:" Larval dispersal for southern rock lobster to support management decisions". Understanding the relationship between spawning areas and the reefs where those larvae subsequently settle is a critical component for effective fisheries management, particularly for species with long pelagic larval dispersal periods such as southern rock lobster, *Jasus edwardsii*. An understanding of larval dispersal patterns highlights areas that are important for recruitment, and these areas can then be targeted by specific management measures with an aim to increase spawning biomass for the species. The project aims to combine an updated connectivity matrix with knowledge of egg production in the different areas of southeast Australia to identify key source areas for *J. edwardsii* larvae. The survival and likely settlement of larvae dispersing from areas, such as in northwest Tasmania, where size limits have been increased, were assessed to increase recruitment of the stock.

The presentation by **Stephen Bradshaw** (University of Tasmania, Australia) was entitled: "Environmental drivers of growth in Southern Rock Lobster". *Jasus edwardsii* have substantial variation in growth rates across their range. This variability creates significant management implications for aspects such as setting size limits and for developing stock assessment models. The spatial scale of variations in growth remains poorly understood due to the limited coverage of the tag-recapture programs throughout time. The study addresses the size at sexual maturity as a proxy for growth and exploring environmental factors that drive its spatial and temporal variation. Size at maturity is closely coupled to the age of *J. edwardsii* and thereby provides a good

indication of female growth rates to that age. Sexual maturity of female of this species can be easily determined through visual inspection, hence significantly more data on size at maturity is available than growth increments from tag-recapture datasets. As such, sexual maturity data we used to consider the appropriateness of spatial size limit zones around Tasmania and consider the trade-off between management complexity and obtaining the best match between size limits and biology.

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ICWL Session: Fisheries Science & Stock Assessment

Co-Chairs: Jim Penn, Eva Planganyi, Simon de Lestang, Geoff Liggins, Emma-Jade Tuffley

The Stock Assessment session encompassed a range of subjects and was very well set up by **Andre Punt's** (University of Washington) virtual keynote address, looking at the past, present and future of lobster stock assessments. Some of his key areas for future focus included adopting some of the progressive work done in the finfish area, such as expanded diagnostic plots, retrospective and jitter analyses. To achieve these goals in an efficient manner, Andre pointed out that collaboration across jurisdictions in terms of model design, development and testing/reviewing was essential.

Individual presentations across the Fisheries Science and Stock Assessment theme canvassed a wide range of subjects that highlighted key areas of contemporary research, which provide both valuable information for empirical assessments, as well as inputs into integrated modelling framework.

The non-stationarity of key stock assessment parameters was a consistent theme across presentations, with the majority of variation being linked to climate change drivers, especially water temperatures. Biological parameters such as natural mortality, reproduction, growth, movement and catchability were all shown to have changed over various study periods and were considered likely to continue to change into the future. The cumulative impacts of these changes can result in variation in species distribution, which also needs to be considered when defining the spatial scale of a stock assessment. e common assumption in a stock assessment model, of a single spatial unit, or spatial units designed to align with management boundaries, were shown to be far from ideal. Rather, they need to be designed primarily around the biology and behaviour of a species.

Improved data quality and or collection methods were also discussed including the importance of independent surveys, the use of artificial intelligence in collecting data, tag-recapture studies to understand movement patterns as well as the ability to directly age spiny lobster.

Finally, a number of presentations covered discard mortality, through the animals being not of a legal status or legal but unwanted having had their claws removed. Consistently, reducing the time a discarded animal remained out of the water or any impact (e.g. claw removal) had increased subsequent survival.

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ICWL Session: **Aquaculture**

Chair: Greg Smith

The ICWL 2023 conference had a significant representation from the aquaculture sector, with 24 presentations specific to this topic. The large number of presentations facilitated the most comprehensive coverage of lobster aquaculture since the inception of the conference in 1977. There was a distinct focus on aquaculture research in Southeast Asia and Europe, with attendees from Australia, New Zealand, Vietnam, Indonesia, England, and Denmark making valuable contributions to the program.

The primary focus of the aquaculture sessions during the conference was, aquaculture production and enhancement of the spiny lobster, *Panulirus ornatus* and European clawed lobster, *Homarus gammarus* L. There was a broad scope across the various presentations, with a mix of specific sessions on animal nutrition, the development of specialised feeds, understanding animal behaviour, physiology, the potential for the manipulation of behaviours or traits through RNA interference, to the development of novel new culture and animal monitoring systems.

One quarter of the presentations were from PhD students, for many of them this was their first international conference. This event provided an ideal platform for them to showcase innovative research and advancements in the field of lobster research to an international audience composed of diverse specialists who share similar interests. Speaking to the students after the conference, they were enthusiastic about the national and global contacts that they had made. They were particularly excited about the diversity of lobster and crab topics that overlapped with their work. The opportunity to gain insights into the work of other researchers and organisations in this captivating research area provided new awareness of alternate directions that may be applicable in their own research projects.

Many of the aquaculture sessions addressed complex issues faced in crustacean aquaculture, with a keen focus on future sustainability through understanding animal biology and the interactions with culture systems and environment. It was pleasing to see the advancements that had been made across a number of crustacean fields of research, with the evolution from small scale experimental research two decades ago to the beginnings of new crustacean industries. This was highlighted in some of the research that has been undertaken with spiny lobsters, a crustacean with a protracted larval phase, on the precipice of the development of a new sustainable commercial industry. The development of cohesive research effort across multiple disciplines to solve complex problems was demonstrated by the number of integrated presentations across the aquaculture sessions. This method of addressing complex issues should be recognised as a blueprint for addressing technical barriers to culture of other high value aquatic species.

The other focus area of the aquaculture session was hatchery rearing and feed development for *H. gammarus* L., where there was a strong focus on animal production for fisheries enhancement. The research being undertaken in European lobster culture is an area of critical

importance to the enhancement of the local fisheries and is recognised for its transformative nature.

The team from the Australian Research Council Transformation Hub for Sustainable Onshore Lobster Aquaculture (Lobster Hub) made a significant contribution to the aquaculture sessions, as well as having a presence in the trade show to answer a range of animal culture questions. The trade show presence from the Lobster Hub, and their lunch cooler bags, were well received by attendees and should be encouraged at future conferences as a way for groups to proactively engage with researchers from all disciplines.

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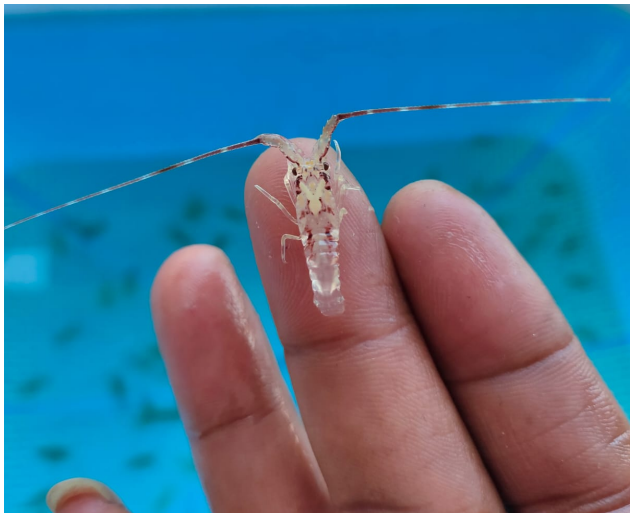
ICWL Session: **Puerulus Growout**

Chair: Clive Jones

ICWL 2023 included four presentations regarding puerulus fishing and the application of fished pueruli for aquaculture. Ph.D. student **Anes Dwi Jayanti** (University of Tasmania) presented on 'The effect of commercial puerulus harvests on adjacent lobster fisheries in Indonesia' and determined that there was no effect of puerulus fishing on nearby lobster fisheries. This conclusion was supported by the presentation of **Dr. Clive Jones** (James Cook University) 'Sustainability of puerulus fishing to supply lobster seed to aquaculture in Southeast Asia' who outlined the extent of puerulus fishing in southeast Asia and supply to aquaculture, and discussed the various considerations for determining puerulus fishing sustainability. Presentations by **Dr. Bayu Priyambodo** (Ministry of Marine Affairs and Fisheries, Indonesia) 'Constraints and opportunities in establishing a spiny lobster aquaculture



Puerulus of Panulirus ornatus *(photo: C. Jones).*

industry in Indonesia and **Dr. Le Anh Tuan** (Nha Trang University, Vietnam) 'Status, constraints and trends of spiny lobster aquaculture in Vietnam' provided excellent overviews of the lobster aquaculture industries of Indonesia and Vietnam. Vietnam now produces more than 3,000 tonnes of farmed *Panulirus ornatus*, primarily using a local Vietnam supply of fished pueruli, and another 3,000+ tonnes of farmed *Panulirus homarus* using locally fished and imported pueruli, sourced from Indonesia. Vietnam possesses the world's only industrial scale lobster aquaculture industry based on its annual harvest of 3 to 5 million pueruli. In Indonesia there is now a confirmed puerulus harvest exceeding 100 million per year and possibly as high as 300 million, composed of 80% *P. homarus* and 20% *P. ornatus*. With such a resource, the opportunity for lobster aquaculture using wild caught puerulus is significant.

Meanwhile, a third country – the Philippines, has identified a substantial puerulus fishery (primarily *P. ornatus*), providing further supply to lobster aquaculture in southeast Asia.

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ICWL Session: **Diseases and Parasites**

Chair: Donald C. Behringer

The Diseases and Parasites session at the 2023 ICWL was smaller than in the past, but perhaps that is a good sign for the health of lobsters down under! The session kicked off with a presentation by yours truly, **Don Behringer** (University of Florida), which gave an overview of the first and still only virus described as naturally-infecting a lobster species – *Panulirus argus* Virus 1 (PaV1) – which infects the Caribbean spiny lobster *Panulirus argus*. The presentation focused on research advances over the past 10 years, highlighting molecular techniques, behavioral ecology, chemosensory ecology, and culminated with the unveiling of a new family of viruses, the "mininucleoviridae", with PaV1 as the first known member. **Tracy Pugh** (Massachusetts Dept. Fish and Wildlife) followed with a talk that honed in on the sublethal effects of shell disease on reproduction in the American lobster *Homarus americanus*. Interestingly, Tracy and colleagues found that female mated at a similar rate in the lab, regardless of infection status, but males delivered less sperm to heavily infected females. However, male disease status did not affect the amount of sperm they delivered to females.

Afternoon tea was followed by a presentation by **Amalia Harrington** (University of Maine, USA) that looked at the intersection of disease and climate change through the synergistic effects of increasing temperature and decreasing pH on the response of American lobsters to *Aerococcus viridans* var. homari, the etiological agent of gaffkemia. They found that increased temperature and decreased pH resulted in a shorter time to death and greater claw autotomy in lobsters exposed to *A. viridans*. **Marianna Rampaul** (Dalhousie Univeristy, Canada) then took us down to the nanoparticle level with an intriguing talk about antiviral responses in northern shrimp *Pandalus borealis* and the northern clearwater crayfish *Faxonius propinquus* (okay, so it's sort of a lobster) challenged by White Spot Syndrome Virus. Turns out these crustaceans exhibit differential gene expression (DEG) indicative of frontline immune responses and the nanoparticle conjugate increased the magnitude of activity by a subset of the genes regulating the immune response. We continued at the molecular level with **Nicolas Argenta** (Dalhousie Univeristy, Canada), who tapped into the transcriptome of impounded American lobsters to look at the regulation of genes in the hepatopancreas in response to impoundment shell disease (ISD). He found that DEG was ramped up in lobsters not exhibiting gross signs of ISD, potentially indicating that those animals have a stronger response against disease. Nicolas also presented recent work on the bacteriome associated with ISD, identifying *Pseudomonas* sp. bacteria as exclusive to infected lobsters. **Eric Schott** (University of Maryland, USA) closed out our talk of Diseases and Parasites with a fascinating

presentation on the Atlantic blue crab *Callinectes sapidus* and its pathogenic virus *Callinectes sapidus* Reo-like Virus 1 (CsRV1). He and his colleagues have found that the prevalence of CsRV1 is strongly linked to climate and crab life history such that crabs in the far north of the northern hemisphere and the far south of the southern hemisphere have the highest prevalence of the virus compared to those in the mid-latitudes. This is particularly interesting because it is at that extremes of their range that blue crabs go dormant in the winter, while they remain active year-round in the mid-latitudes. There was only one poster on disease, also presented by **D. Behringer** and colleagues, that focused on the discovery and proliferation of an egg-parasite in the Caribbean spiny lobster *P. argus*. The nemertean worm *Carcinonemertes conanobrieni* was first reported in 2016, but has since risen in prevalence from 7.5% to 100% among gravid females in the Florida Keys in 2023. The parasite is the primary cause of embryo mortality and significantly affects reproductive output. Research is underway to determine the distribution of *C. conanobrieni* around the Caribbean.

I think I can speak for all the presenters in the Diseases and Parasites session when I offer my sincerest thanks to the organizers of ICWL 2023 and for their perseverance despite the challenges that began in 2020. See you all in Mallorca in 2026!

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ICWL Session: **Industry Day**

Co-Chairs: Peter Rogers and Matt Taylor

The agenda also included an Industry Day which provided a broad range of topics of particular relevance for those involved in fishing, aquaculture or at the business end of processing, marketing or support services. The Industry Day session, allowed **Fedele Camarda** from Western Rock Lobster, to outline to delegates, an entertaining family history perspective across generations, the W.A. history of rock lobster management from its origins to today. The industry day featured 30 presentations covering topics of interest including gear research, ghost fishing, lobster translocation, reducing plastic, summary aquaculture development overviews, methods to improve lobster handling, results of seismic and heatwave events, lobster global trading, work on pot design and industry-led research projects.
One event of special note was a panel discussion by seven representatives - **Bruce Cockman** (Western Rock Lobster)**, Kathleen Reardon** (Maine Dept. Marine Resources, USA)**, Julie Hills** (New Zealand Rock Lobster)**, Clive Jones** (James Cook University, Australia)**, Erwan Quemeneur** (CDPMEM29, France)**, Raul Cruz** (Fundação Cearense de Apoio ao Desenvolvimento Científico e Tecnológico, Brasil)**,** and **Melanie Giffin** (Prince Edward Island Fishermen's Association, Canada) - as well as delegates in the audience. They were requested to define the top three issue/challenges facing future management and sustainability in their lobster and crab fisheries. The results were diverse but defining, very much depending on jurisdiction and state of lobster research and management. Clearly issues around the

uncertainty of climate change impacts, requirements for data and facilitating collection of more accurate and wider set of data requirements, management of protected species interactions from fishing, economic viability of industry and accommodation of indigenous and artisanal requirements, rated highly. The emerging pressures of spatial squeeze on fisheries access from wind farms, marine parks and growing uses of the marine domain by multiple developments and users was also a significant issue. Other issues raised included bycatch management, insufficient compliance, trade and geopolitical impacts and impacts of pollution.

In the summary presented to this event, Ecosystem-Based Fishery Management was recognised as a valuable framework for future management of lobster and crab resources in a changing world. This appeared to apply equally to EBM approaches that requires integrated decision making and planning across all users of the marine environment spatially and from a resource use perspective. Whether ocean policy developments provided a sufficient evaluation decision framework adequately resourced across multiple jurisdictions at sufficient scale to be effective was not known. The conference was left with the challenge to develop such a framework through undertaking specific research into various governance options, institutional and legal requirements to provide effective management across multiple and diverse uses of the ocean resources, a matter requiring investigation and perhaps a topic for a future ICWL conference.

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ICWL Session: Recreational Fishing

Chair: Claire Smallwood

The presentations in the Recreational Fishing Session at ICWL 2023 provided an interesting overview of research and approaches to data collection to delegates and industry attendees who may have traditionally been more familiar with commercial aspects of fisheries for rock lobster and blue swimmer crabs. The different approaches taken to collecting data from recreational rock lobster fishers occurring in Western Australia and on the east coast were highlighted.

In Western Australia, an integrated survey approach using phone recall and boat ramp surveys are used to provide estimates used for monitoring the Western Rock Lobster fishery. Presentations focused on corroborating data obtained from the different survey approaches and highlighted how different aspects of the recreational fishery, such as the human dimensions of fishers, can be explored using these data collection tools. This presentation found good alignment between data collected using the two survey approaches. The phone recall surveys used in Western Australia were discussed in more detail in another presentation which focused on how survey errors are minimised. Phone recall surveys have low exposure to many error types, with recall bias the most likely to occur. However, after comparing different recall periods this presentation highlighted that rock lobster fishers provided similar data across different recall periods. The questions from the audience in the recreational fishing session also highlighted that Western Australia is

fortunate to have fishers who are engaged and involved with providing data for our surveys, with high response rates for all survey methods.

In contrast to the survey sampling approaches used in Western Australia, a novel tagging approach with mandatory reporting is used in Victoria on the east coast of Australia for their Southern Rock Lobster fishery. This was a really insightful presentation which included learnings from the first few years of implementing this approach, and also highlighted the differences in the recreational fisheries for rock lobster between these two jurisdictions. The final presentation in this session shifted the focus to the recreational fishery for blue swimmer crabs in the Peel-Harvey Estuary and explored the potential for catch re-construction to help fill knowledge gaps and inform management. The data requirements and different options for this approach were explored and preliminary analysis revealed changes in catch from the recreational fisheries over time.

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ICWL Special Session in Honor of Bill Herrnkind: **Behavior**

Chair: Mark Butler

Professor William "Doc" Herrnkind

(photo: M. Bulter)

The "Behavior Session" at the 2023 ICWL was preceded by a formal ceremony in which the Behavior Session at this and all subsequent meetings are dedicated to **William "Doc" Herrnkind**, a Professor at Florida State University (USA) for over 40 years, and a pioneer in the *in situ* study of lobster behavior. At the start of Herrnkind's career in the 1960's, the scientific literature portrayed lobsters as lowly scavengers, limited in sensory capacity, and driven by ill-defined instincts – simple beasts that were grist for increasingly valuable fisheries. In his research, Herrnkind leaned on his classical training in ethology while embracing new undersea technologies – scuba diving, undersea human habitats, and acoustics – pioneering the *in situ* study of lobsters by exploring their behavior and ecology "eyeball to eyeball".

Mark Butler, chair of the Behavior Session and a Professor at Florida International University (USA), led off the session with a talk entitled "*The Gill-Oxygen Limitation Theory (GOLT): A unifying theory for the*

ecology of lobsters?" co-authored by Morgan Jarett and Daniel Pauly. Developed to explain regularities in the growth, respiration, and reproduction of fishes, GOLT has since been extended to other water-breathing ectotherms (WBE) – including decapod crustaceans. It posits that key features of life sustaining processes can be explained by the scarcity of oxygen available in the sea and further limited by the exponential disparity between the growth of the essentially 2-dimensional respiratory surface areas (e.g., gills) of WBE relative to the 3-dimensional volume of their bodies. Butler explained the theory in detail and provided evidence of its applicability to explaining limits to the growth, reproduction, and behaviors possible by large individuals of lobsters and other decapods.

"*Heading home: Displaced juvenile and subadult Caribbean spiny lobsters show strong orientation toward home dens*" was the title of the second presentation given by **Michael Childress** (Clemson University, USA) with coauthor Rodney Bertelsen. Caribbean spiny lobsters (*Panulirus argus*) migrate as adults using the Earth's magnetic field for map and compass orientation, but the dispersal ability of juveniles is not well characterized nor is it known if they too use magnetic orientation. Childress described a series of studies in which they displaced juvenile lobsters from their dens in hardbottom and coral patch reef habitats and used acoustic telemetry to track their movement. Although some handling effects were noted, when displaced away from their point of capture, the distance and angle that juveniles travelled was indeed directed toward the point of capture suggesting that map and compass orientation appears early in lobster ontogeny. However, it is still unknown what triggers lobsters to transition from residential homing to long distance dispersal.

An entertaining presentation by **Benjamin Gutzler** (Wells National Estuarine Reserve, USA) followed, titled "*Seafood takeout: datalogger measurements of lobster foraging activity in the wild"* coauthored by Jason Goldstein and Win Watson. By combining a new backback datalogger design (C-HAT) providing information on mandibular movement and heart rate with acoustic telemetry, Gutzler and colleagues coupled measurements of physiological state with fine-scale movements of American lobsters (*Homarus americanus*) in their natural environment off the coast of New England. After laboratory calibrations of the datalogger output, lobsters equipped with the C-HAT backpacks were tracked in the wild within an acoustic positioning array. Lobsters fed and moved at all hours, although most activity was nocturnal or crepuscular. Bouts of feeding were easily distinguishable by changes in movement, sequences of mandible movements lasting 1–5 minutes, and elevated heart rates. These data provide new insights into the activity patterns of lobsters and offer an improved understanding of the motivations for the daily movements of this iconic species.

Daphne Oh (University of Western Australia Oceans Institute, Australia) with coauthors Tim Langlois, Michael Brooker, Simon de Lestang and Jason How, next gave a presentation titled "*Early juvenile western rock lobsters Panulirus cygnus (George RW, 1962) actively associate with seagrass assemblages*". A heatwave in Western Australia in 2010-11 that caused extensive damage to coastal habitats and recruitment into the Western Rock Lobster (*Panulirus cygnus*) fishery generated interest in the

factors influencing survival of early benthic juvenile benthic *P. cygnus*. Surveys in common nearshore habitat assemblages found early juvenile lobsters strongly associated with seagrass, particularly *Amphibolis* at high shoot densities. Using Y-maze bioassays, Oh then tested early benthic juvenile habitat choice based on prey scent and habitat types but found that habitat choice was complex and driven by multiple benthic habitat cues.

The next presentation focused on "*Comparing the predictive accuracy between preferential and spatially balanced sampling designs for modelling aquatic vegetation with remote sensing and machine learning*", a talk by **Stanley Mastrantonis** (University of Western Australia) with coauthors Ben Radford, Tim Langlois, Simon de Lestang and Sharyn Hickey. Although not a presentation on lobster behavior *per se*, the subject of this talk is critical to effectively mapping and monitoring the changing spatial dynamics of submerged vegetated habits critical to the recruitment of *Panulirus cygnus* and the Western Rock Lobster fishery. The type of sampling designs used in remote sensing studies (e.g., preferential, random, grid-based, spatially balanced sampling) can greatly influence model accuracy and predictions. Mastrantonis compared model outcomes of aquatic vegetation for five coastal sites across the midwest of Western Australia with data from two sampling designs (preferential vs. spatially balanced designs) using in-water imagery, an aquatic vegetation index derived from the Sentinel-2 mission, and machine learning models. He validated the models using spatial cross-validation and found appreciable differences in the model outcomes between the two sampling strategies with spatially balanced designs performing better.

The Caribbean spiny lobster, Panulirus argus (photo: P. Briones)

Changes in the role of lobsters in the trophodynamics of coral reefs that have been drastically altered in the Anthropocene was the subject of **Casey Butler's** (Florida International University and Florida Fish & Wildlife Conservation Commission, USA) presentation titled "*You are what you eat, lobster-style: Trophodynamics of Panulirus argus and P. guttatus varies with coral reef habitat degradation*" with coauthors Mark Butler and Tom Matthews. The phase-shift on Florida's coral reefs from coral- to macroalgae-domination has repercussions for food web dynamics, but with differential effects depending on the life histories even of closely related species. Butler examined this by comparing changes in the diets of two spiny lobsters that co-occur on Caribbean coral reefs but have contrasting ecologies. The Spotted Spiny Lobster (*Panulirus guttatus)* is a reef obligate and forages on coral reefs, whereas the Caribbean Spiny Lobster (*P. argus)* uses reefs facultatively and forages primarily off the reef and is the target of the Caribbean's prize fishery. She surveyed 22 coral reefs and evaluated coral reef habitat quality, lobster nutritional condition, and trophodynamics of both lobster species using DNA metabarcoding of lobster gut contents along with bulk (^{13}C and ^{15}N) and compound-

specific stable isotope composition of lobsters, potential prey, and autotrophs. Her compelling results reveal that *P. guttatus* occupies a higher trophic position on coral reefs than does *P. argus*, and its diet changes dramatically with reef habitat quality – becoming more of generalist on degraded reefs - whereas the diet of the primarily off-reef foraging P. argus remained unaffected by reef degradation.

The final presentation of the Behavior Session switched to focus on crabs instead of lobsters and was provided, in a humorous "tongue-in-cheek style", by **Andrew Kough** (Shedd Aquarium, USA) and titled "*Scales of connectivity between North American Callinectes sapidus populations from biophysical models of adult movement and larval transport*" and coauthored by Donald Behringer, Jamie Bojko, Louis Plough and Eric Schott. The team's goal was to examine how changing life history drives the dispersal and connectivity of blue crabs in the USA across a climatic gradient from subtropical Gulf of Mexico waters through seasonally dormant populations in Maine. They used two biophysical models of connectivity to estimate broad scale adult and larval dispersal along coasts and between estuaries. As expected, larval connectivity exceeded that produced by adult dispersal by an order of magnitude, but model results suggested that scuttling adults could maintain population connectivity by crossing local oceanographic boundaries. Model-derived connectivity patterns will next be compared with genomic estimates and together will be used to examine the spatial epidemiology of disease in blue crabs.

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ICWL Special Session in Honor of Stan Cobb: **Life Cycles**

Co-chairs: Rick Wahle and Jason Goldstein

Professor Stan Cobb (photo: Cobb collection)

This session was named in honor of **Professor J. Stanley Cobb** of the University of Rhode Island, USA. Stan's famous collaboration with **Bruce Phillips**, CSIRO Australia, launched the first meeting of International Conference and Workshop on Lobster Biology and Management in 1977, which led to their co-editing the first compendium of lobster research in the two-volume *Biology and Management of Lobsters* in 1980. A consistent theme in Dr. Cobb's work was to incorporate a better understanding of biology, ecology, and behavior in lobster fisheries stock assessment and management. It is therefore fitting that this session's theme focus on the implications of life history processes for lobster and crab population dynamics and management of the fisheries they support. The Cobb session will henceforth be a continuing feature of the

ICWL. This first year of the Cobb session comprised six talks on the American lobster, two on portunid crabs and one on the Caribbean spiny lobster.

The first four talks focused on the conspicuous and puzzling decoupling of the spawner-recruit relationship in the Gulf of Maine lobster population as revealed by declines in the larval settlement index over the past decade despite the historic surge in spawner abundance. **Rick Wahle** of the University of Maine, USA, set the stage for this series by advancing the hypothesis the following studies aimed to test, namely that climate related declines in the abundance of energy rich, cold-water copepod *Calanus finmarchicus* has been a key driver of declines in lobster recruitment over the past decade. In the following talk, **Joshua Carloni**, New Hampshire Fish and Game Department, USA, illustrated that the declines in lobster recruitment not only correlated with declines in the abundance of their copepod prey, but also with an increasing mismatch in their phenology. In the next talk, **Alex Ascher**, of UMaine, presented new molecular analysis of larval lobster gut contents suggesting that larvae in the coastal Gulf of Maine have a crustacean-dominated diet, and selectively feed on *Calanus* despite its declining abundance. In a separate analysis Alex suggested we cannot rule out the possibility the declining size at onset of maturity of female lobster may have adverse effects for larval performance, and possibly contributed to the recent lobster recruitment declines. In the fourth and final talk of this sequence, **Evelyn Layland** also of UMaine, presented results of her experiments on larval lobster pursuit and handling of zooplankton prey. Her video clips and functional response experiments illustrated the dramatic increase in prey pursuit and handling capacity in the transition from larval to postlarval stage, as well as the high energy gains to be had by consuming *Calanus*.

Next, **Heather Glon** of Maine's Department of Marine Resources described the department's relatively new larval sampling program in the context of their longer-standing program of multi-life stage monitoring. An early outcome of the analysis of the larval time series was the observation that mean larval carapace length has varied annually. Whether this variability relates to the quality of planktonic food, maternal effects or both remains to be seen.

In the final talk of the American lobster series, **Jason Goldstein** of Wells National Estuarine Research Reserve in Maine, addressed the acute challenges lobster populations face in a warming climate at the southern end of their range. In southern New England, where epizootic shell disease (ESD) has been prevalent since the late 1990s, they found female lobsters in their collections to have lower fecundity than those reported from the 1980s, before ESD plagued the region. However, they reported no difference in fecundity between diseased and disease-free females; nor did they see differences in egg protein content between the two groups except in larger females.

Turning to portunid crabs, **Charlie Maus**, Western Australia Department of Primary Industries & Regional Development, presented a talk on developing an Aboriginal mud crab (*Scylla serrata* and *S. olivacea*) fishery in the Kimberley region of Western Australia through a pilot trapping and distribution survey in King Sound. The next talk by **Alexandra Schneider** of the Virginia Institute of Marine Science, USA,

gave an overview of a sampling program to evaluate factors contributing to variability in fecundity of female blue crabs *Callinectes sapidus* in Chesapeake Bay, including maternal size, spawning history, egg stage, location, and sperm quantity in the seminal receptacle (the first to do so). The statistical model under development will provide new insights to inform management of the Bay's iconic crab fishery.

Finally, in the single presentation on spiny lobsters in this session, **Erica Ross** of Florida Fish and Wildlife Commission, described the conflict between traditional commercial trap fishers and the more recent inclusion of commercial divers harvesting lobster from artificial shelters called "casitas" they deploy. As the use of casitas has increased, trap fishers complain that their catch has declined, a trend potentially confounded by overall declines in lobster abundance. Ross described the challenge and data needs state fishery managers facing in resolving the issue.

Taken together the session's presentations underscored the need for accurate cradle-to-grave fishery-dependent and fishery-independent monitoring of multiple life stages to inform fishery stock assessment and management as was advocated by the late professor Cobb.

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ICWL Special Session in Honor of Bruce Phillip: **Recruitment**

Chair: Adrian Linnane

Dr. Bruce Phillips (photo: Phillips collection)

Dr. Bruce Phillips co-founded the ICWL with **Professor Stan Cobb** in 1977, and as an outcome of that conference they co-edited *The Biology and Management of Lobsters* (Cobb and Phillips 1980 vol 1 and 2), the first multi-author compendium of biological and fishery research spanning the diversity of lobster taxa. Bruce continued to edit several additional books on lobster biology and management over his career. He also pioneered the development of larval collectors and predictive indices for the Western rock lobster *(Panulirus cygnus)* in the 1970s and '80s. As a tribute to Bruce's contribution to lobster science the ICWL organizing committee has decreed that the Phillips recruitment session will be a permanent feature of the ICWL. Fittingly, this first session focused on how various recruitment indices are utilised to forecast levels of both catch and catch rate within lobster fisheries.

Emily Hutchinson of the Florida Fish and Wildlife Department, USA, opened the session with a presentation detailing how postlarval settlement drives future commercial landings of Caribbean spiny lobster (*Panulirus argus*) in Florida. Multiple time lags showed strong correlation to landings, suggesting that there is yearly variability in time to recruitment to the fishery.

Adrian Linnane of the South Australian Research and Development Institute then showed how postlarval monitoring of Southern Rock lobster (*Jasus edwardsii*) in South Australia was used in harvest strategy evaluation. Based on a 3-year time lag from puerulus settlement to legal-sized fishery recruitment, observed estimates for catch, catch rate and egg production closely followed predicted model estimates.
Staying with Southern Rock Lobster, in Tasmania, **Rafael Leon**, University of Tasmania, Australia, highlighted that collecting postlarval data can be costly and therefore explored alternative indicators such as pre-recruits (animals 10 mm below the size limit). Strong correlations were observed between recruits and pre-recruits at lower sampling cost levels compared to postlarval monitoring.

Jules Selles of the Muséum National d'Histoire Naturelle, France, used similar pre-recruit indices to improve harvest control rules for the Saint-Paul rock lobster (*Jasus paulensis*) fishery in the French Exclusive Economic Zone of Saint-Paul & Amsterdam islands in the South-East Indian Ocean. Specifically, the performance of empirical harvest control rule candidates based on pre-recruit indices was evaluated and tested based on their ability to trigger catch limit adjustments in response to a change in abundance before the change was reflected in the fishery.
The session concluded with a presentation from **Lydia White** of the University of New Brunswick, Canada, who used benthic recruitment densities as an indicator of future fisheries recruitment of American lobster (*Homarus americanus*) in Atlantic Canada. Significant positive relationships between modelled recruitment indices and fisheries landings were identified in three Lobster Fishing Areas, thereby indicating that benthic indices can assist in strategic fishery decision making for Canadian lobster resources.

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Nick Caputi enjoys a well earned beer (or two) with Carly Daniels and friends after a long day of talks at the ICWL. (Photo: K. Ley Cooper)

OTHER NEWS

Project Rock Lobsters of the World

From: Roger and Catherine Swainston

We were very pleased to take part in the recent International Conference and Workshop on Lobsters and Crabs in Fremantle. It was an opportunity for us to show the work we have completed thus far on our project; to paint life size portraits of all the world's species of Rock and Spiny Lobsters (and two species of Clawed Lobsters) from specimens.

Part of the display at the 12th ICWL. (Photo: R. Swainston)

Our aim is to create the definitive suite of images of these magnificent creatures. They will (eventually) be presented in a folio sized limited edition book for collectors, as well as a more modest edition for the general public. This latter will also present as far as possible

Photographing the specimen of Panulirus ornatus which was the star of the Fremantle 2023 Conference, spending the entire time in an aquarium there. It was kindly provided to me after the conference by ARC Research Hub for Sustainable Onshore Lobster Aquaculture, Institute for Marine and Antarctic Studies, Tasmania.(Photo: R. Swainston)

the current state of knowledge of the members of this fascinating group.

At the conference we displayed life size reproductions of most of the 18 species Roger has painted so far, as well as a number of portraits of crab species. Prints of these were also available for sale and many participants went home with a portrait of their favourite research subject. The Conference was a great success, we were able to meet many of the participants and make some great contacts for sourcing the remaining species

We have travelled widely, including to Cabo Verde, Guadeloupe, Costa Rica, New Zealand, Tahiti, the Marquesas Islands, Easter Island, Reunion Island and France.

We have sourced 20 of the 36 (species and subspecies of) Rock Lobsters and the European Clawed Lobster. This work relies greatly on local knowledge and would not

Drawing the specimen, this is a meticulously slow process and can take anything up to 9 or so hours to complete. The specimen has now been recorded and the painting will be undertaken as soon as time permits. (Photo: R. Swainston)

be possible without assistance from researchers and fishermen. When a specimen has been obtained Roger will make a photographic recording of live colour and then make a detailed, measured drawing using calipers for accuracy. These are taken back to the studio for the creation of the life size portraits.

A list of species which we are yet to obtain is set out below, anyone who is able to provide us with a suitable specimen of any of these will be the recipient of a museum quality reproduction of the life size portrait when it is completed.

Jasus frontalis
Jasus lalandii
Jasus tristani (*J. paulensis* from Tristan da Cunha)
Palinurus barbarae
Palinurus charlestoni
Palinurus delagoae
Palinurus gilchristi
Panulirus bruneiflagellum
Panulirus homarus (ssp *P. homarus rubellus, P. homarus megasculpta*)
Panulirus inflatus
Panulirus japonicus
Panulirus marginatus
Panulirus meripurpuratus
Panulirus polyphagus
Panulirus stimpsoni

The work we have completed thus far can be seen on our website, and we welcome any enquiries or offers of assistance by email.

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The most recent addition to the collection, thanks to Anthony Pere and the French Administration for bringing 4 specimens of J. paulensis back to Reunion Island. Roger travelled there in May of 2023 to draw and photograph them, this is the portrait of one.

An American in the Levant: First record of *Homarus americanus* in the Southeastern Mediterranean

From: Ehud Spanier

Despite their large natural geographic and ecological dispersal potential and the economic importance of many species, there have been only two reports on non-indigenous lobsters in the southeastern Mediterranean. These included one report of a single Indo-Pacific *Ornate* spiny lobster *Panulirus ornatus*, and a documentation of a single exuvia of the tropical Long-legged spiny lobster *Panulirus longipes longipes*. On December 31, 2022, a sport fisherman noticed a clawed lobster in the central Mediterranean coast of Israel, near the ancient Herodian aqueduct, north of ancient Caesarea (32º30′48.3″N; 34º53′44.0″E). The lobster was observed in very shallow water (20-30 cm deep) in a calm sea (seaward eastern winds). The bottom of this area is sandy covered with rocks and the lobster was first detected hiding under one of these rocks. The fisherman removed the lobster with a dip net and put it in a plastic bucket (Figure 1). He then released the lobster back to the water where it moved and hid again under a rock. This observation was supported by a report from a tourist guide that took pictures of two clawed lobsters on December 30, 2022, at the same exact site. He removed one of the lobsters from the water and photographed it (Figure 2). before returning the lobster to the water where the two lobsters continued to interact (Figure 3). The species lobsters were identified, and their sizes were estimated. Restaurants in the nearby historic Caesarea were questioned about using live clawed lobsters as well as the only importer of clawed lobsters to Israel.

Figure 1. *An American clawed lobster (Homarus americanus) caught (and released) in the coast of Caesarea, Israel, on December 31, 2022. (Photo: Yaron Koren).*

The lobsters were identified as *Homarus americanus* since the rostrum was with a ventral tooth (Figure 2, inset) typical to *H. americanus* (Holthuis, 1991,) and not to *H. gammarus.* Also, the colors were those described for *H. americanus,* especially the dorsal spines on both rostrum and chelipeds that were of orange-reddish coloration (Figure 2), compared to those of *H. gammarus* which are always white (Jørstad et al., 2007). The carapace lengths of the lobsters were 92 and 94 mm. The general coloration of the lobsters was dark-olive to rusty-brown, with some orange stains. The chelipeds had some orange margins and they, as well as the base

of the telson, were mottled with dark-greenish black spots. The color of the uropods was mostly of lighter olive coloration with darker margins. Since no picture of the ventral side of the lobsters was available, it was not possible to determine the sex of the lobsters. One of the lobsters looks like it has some deformed claws.

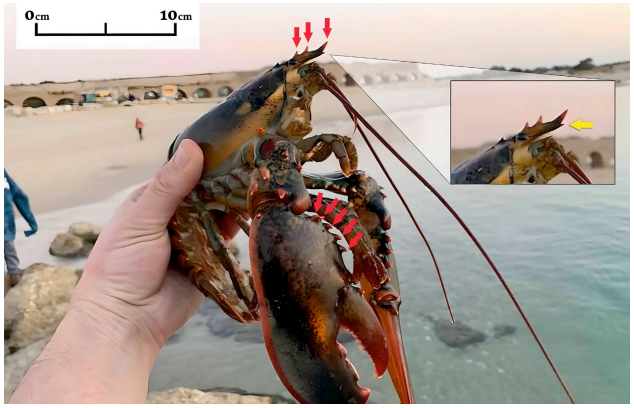

Figure 2. *A side view of an American clawed lobster (Homarus americanus) caught (and released) in the water of the Aqueducts Beach of Caesarea, Israel, on December 30, 2022. Red arrows indicate orange-reddish spines on rostrum and cheliped. Inset: enlargement of the rostrum. The yellow arrow points to the tooth on the ventral side of the rostrum, typical to this species. (Photo: Michael Tuval).*

The origin of these lobsters is unknown. However clawed lobsters are imported live for gourmet restaurant in Israel (including to restaurants of Caesarea), so perhaps this is the way by which they arrive to the Israeli coastal water. The only importer of American clawed lobsters to Israel reported that his company imported live lobsters from New England, North-Eastern USA, in weight of 600-640 grams each. This weight range corresponds with the carapace lengths of the lobsters observed in Caesarea (e.g., Hoenig et al., 2015). It is also like the sizes reported for singles *H. americanus* fished in the northern Adriatic (Pavičić et al., 2020) and Northern Aegean (Kampouris et al., 2021) Seas. It is postulated that these lobsters, which are expensive in Israel, were purchased and set free from a holding tank of a luxurious restaurant (restaurants in Caesarea occasionally serve *H. americanus*) or released from a passing cruise ship. This had happened in northern Europe despite the strict regulations aimed specifically at preventing the introduction of this species into the NE Atlantic (e.g., Jørstad et al., 2007 and references therein). The deformed claws of one of the lobsters, possibly caused by banding during transport, may also indicate live food trade as a source of the lobsters. The gradual appearance of *H. americanus* in the Mediterranean from north-west to south-east are not assumed to explain their appearances that could be associated only with accidental fishing/detections.

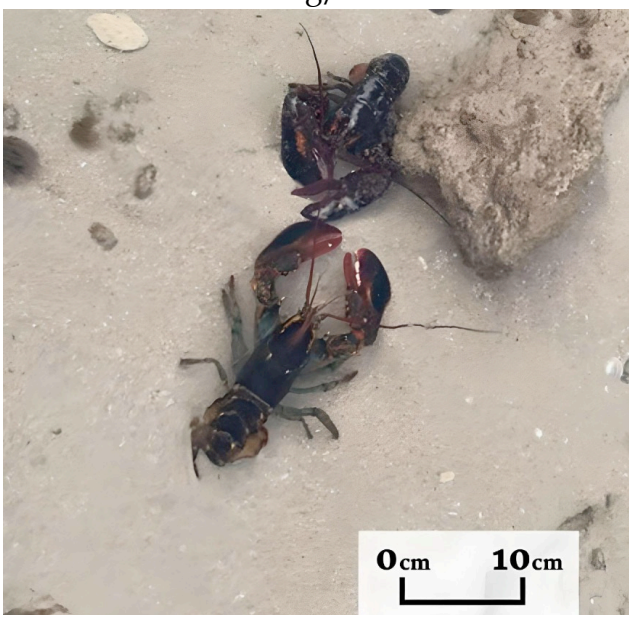

Figure 3. *Interaction between two American clawed lobsters (Homarus americanus) in the coast of Caesarea, Israel, on December 30, 2022. (Photo: Michael Tuval).*

This is the first record of this species, or any clawed lobster, in the warm Southeastern Mediterranean Sea. The water temperature at the site was estimated to be ~18-19 ^{o}C. These lobsters may or may not

survive in the southeastern Mediterranean until the summer (if not injured by the force of the breaking waves in this shallow water, fished by humans or preyed upon by local predators). Yet as water temperatures start rising in late May - beginning of June to 24 ^{o}C or more and especially in July-September when water temperatures may reach over 29 ^{o}C (Ozer et al., 2022), with even higher values in shallow water, they will not be able to survive let alone mate and brood eggs. Theoretically they can move under the thermocline that develops in the summer, but this may be too deep (~50 – 60 m) and far offshore for them to travel.

The physiological limits for benthic American clawed lobster are >20°C (e.g., Wahle *et al.*, 2015). Lethal limits may be under 30°C and high water temperatures may negatively affect fecundity, reproduction, and growth (e.g., Koopman et al., 2015). Discussing the initial records of *H. americanus* in the northern Mediterranean coasts, Pavičić et al. (2020) and Kampouris et al. (2021) referred to possible ecological risks involved if these were persistent introductions, and not just isolated incidents. In this case they suggested that *H. americanus* might negatively impact Mediterranean biodiversity and affect ecosystem services. It might compete with its indigenous congener, *H. gammarus,* and other native lobsters that are important for the local fisheries. This risk does not exist in the extreme eastern part of the Mediterranean, east of Crete, since this region is out of the distribution range of *H. gammarus* (Holthuis, 1991). It is, however, recommended requiring that live markets/importers of *H. americanus* etch a code on the carapace or claws of the imported lobsters to allow tracing the origin of these animals if released or escape to the Mediterranean. For more details see Spanier (2023).

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Growout of wild caught puerulus in Southeast Asia

From: Clive M Jones, Tuan Le Anh and Bayu Priyambodo

Development of spiny lobster aquaculture has been actively sought for several decades and subject to considerable research and development, primarily focussed on the hatchery technology to produce post-larval lobster pueruli in land-based breeding and larval rearing facilities. Notwithstanding the great progress that has been made in establishing such commercial hatchery technology, aquaculture of spiny lobsters has developed anyway, using wild caught pueruli, that in some locations are available in high abundance. Considerable research and development effort has also been applied to the on-growing of wild caught pueruli, including for aspects of puerulus fishing, handling and transport, and of nursery and growout technologies.

Lobster farms in Van Phong Bay, Vietnam. (photo: C. Jones).

Spiny lobster aquaculture, using a reliable supply of puerulus fished from the wild, is now established in Vietnam and developing in Indonesia and the Philippines. Vietnam is the only country in the world where farming of lobsters is well established, commercially successful and of significant scale. Vietnam currently produces more than 2,000 tonnes of premium grade lobsters of the species *Panulirus ornatus*, that are exported to China where demand is very strong and premium price is offered, often exceeding $US50 per kilogram. The supply of the 'seed lobsters' the colloquial name for pueruli, for *P. ornatus*, is primarily domestic. A targeted fishery for pueruli is well developed in the northern coastal region from Quang Binh in the north to Phu Yen province in the south. The puerulus fishery is considered to be fully developed with a stable number of fishers, fishing gear and catch per unit effort. From around 2006 to present, the annual

catch of *P. ornatus* pueruli ranged from 3 to 5 million individuals, all of which are sold to Vietnamese buyers who transport the seed to the preferred growout region in central south Vietnam, from Phu Yen to Binh Thuan province. The industry is valued at over $US200 million. In addition to the growout of *P. ornatus*, a similar industry has developed for on-growing a secondary species, *Panulirus homarus*. A smaller number of *P. homarus* seed lobsters are captured in the puerulus fishery in northern Vietnam, ranging from 1 to 2 million individuals per year. These are on-grown using the same technologies, although the market for the harvested lobsters is primarily domestic. *P. homarus* farmgate price is lower, averaging $US30 per kilogram.

This success of Vietnam in farming wild caught seed lobsters led to significant interest in Indonesia where a similar fishery for seed lobsters was developing since around 2013. This seed fishery has developed since, and now boasts a catch more than 20 times greater than that of Vietnam. 100 million seed were estimated to have been fished in 2019 and the number now being caught in 2023 possibly exceeds 300 million. This presents an enormous opportunity to Indonesia to develop lobster growout. However, the growout of lobster in Indonesia remains insignificant due to adverse government policy and lack of farmer knowledge and skills. In Indonesia, approximately 80% of the seed caught are *P. homarus* and 20% *P. ornatus*. Government policy is shifting to favour lobster aquaculture, and the skills shortage can be addressed through training and technology exchange. In Indonesia, a significant socio-economic benefit has arisen for the puerulus fishery which extends from the western, southern coastline of Sumatra eastwards along the southern coastlines of Java, Bali, Lombok and Sumbawa. The seed fishery involves simple technologies and is primarily the province of impoverished coastal villages with few alternative livelihood options. Price paid per lobster seed varies considerably, but is most often above one USA dollar per individual and sometimes exceeds $US3. Nightly catches of 10, 20 or more seed per fisher generates significant income. The low risk, high income, immediate cash flow nature of seed fishing has to some extent dampened enthusiasm to on-grow the lobsters, a process involving considerable capital expenditure, a protracted growing period exceeding 1 year and most often 2 years to achieve 1 kg lobsters, and relatively high risk. Demand from Vietnam for more seed than the domestic supply has provided a ready market for the Indonesian-caught lobster seed. The Vietnam industry has consequently grown in respect of on-growing *P. homarus* using imported seed from Indonesia. Production of aquacultured *P. homarus* in Vietnam now exceeds 5,000 tonnes with markets available to Taiwan, Japan and China.

The Philippines has recently also identified high abundance of pueruli settling in the east of Mindanao and further north. A fishery is developing, and there is great interest in on-growing these seed to establish a domestic lobster aquaculture industry. Nevertheless, the Philippines faces similar challenges to Indonesia in regard to competing economic appeal of seed fishing with immediate sale in contrast to on-growing lobsters to market size. The Philippines currently exports most of its fished lobster seed, but like Indonesia, is poised to establish significant on-growing of

lobsters with appropriate government support and capacity building.

The extraordinarily high abundance of naturally settling seed lobsters in selected areas is likely due to a confluence of suitable environmental conditions that enable high concentrations of late-stage larvae (phyllosoma) near the coast. Responding to environmental cues from the coast, late-stage larvae moult (metamorphose) to the puerulus stage and actively swim towards the coast seeking suitable settlement habitat. These areas have been termed hotspots, as the availability of settling seed is much higher than other similar areas. Such hotspots are now recognised in the central northern coast of Vietnam – supplying their growout industry – and the central southern coast of Indonesia. Natural mortality of the seed lobsters in these areas is correspondingly high due to exhaustion of finite energy reserves (the puerulus is a non-feeding stage relying on bodily energy reserves stored during the larval stage), fish predation and limited settlement habitat. Consequently, responsible fishing of these seed is likely to be sustainable, as the seed are intercepted with fishing gear just prior to inevitable death.

The economics of both seed fishing and on-growing involve relatively modest capital and operating costs and production of high-value product that provides significant economic and social benefit to the communities involved. Although several health and disease issues have impacted spiny lobster farming, they can be effectively managed through good nutrition and husbandry. The future for tropical spiny lobster aquaculture based on the on-growing of wild caught seed appears to be very positive, particularly for developing countries in the Asian region, where seed are readily available, suitable growout locations are present and where costs of production are relatively low. It is expected that lobster aquaculture will continue to develop in the region.

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The stunning coastline near Cape Naturaliste, Western Australia (photo: R. Wahle).

ANNOUNCEMENT

The next ICWL…

13th International Conference and Workshop on Lobster Biology and Management Mallorca, Spain October 2026

From: David Diaz and Nick Caputi

Cape Fomentor, Mallorca (photo: R. Wahle)

At the end of the 12th ICWL there was an announcement by the Spanish delegates of their intention to hold the next ICWL conference at Mallorca, a significant tourist location in the Mediterranean, in October 2026.

ICWL2023 conference attendees welcoming the announcement of the next ICWL in Mallorca in October 2026. (Photo: Lauren Dunkley)

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