NAUTILUS COLLABORATION

Ethics of Aquatic Invertebrate Management and Farming

Sarah Wahltinez
Aquatic Animal Welfare Veterinarian
swahltinez@nautiluscollaboration.com

FEBRUARY 2025 | For RSPCA Animal Welfare Seminar

Today's Presentation

1. What is animal welfare?
2. Welfare Assessments
3. Challenges in Aquatic Invertebrate Welfare
4. Safeguarding Invertebrate Welfare
5. Case Studies

What is Animal Welfare?

The NC Definition of Animal Welfare

Animal welfare encompasses an animal's physical wellbeing and experiences. Using a Five Domains approach[1], an animal's nutrition, physical environment, health, and behavioural interactions impact its experiences and feed into positive, neutral, or negative animal welfare.

[1]Mellor, D.J., Beausoleil, N.J., Littlewood, K.E., McLean, A.N., McGreevy, P.D., Jones, B., Wilkins, C., 2020. The 2020 Five Domains model: Including human–animal interactions in assessments of animal welfare. Animals 10, 1–24.

What is Animal Welfare?

- How an animal is coping with the conditions in which it lives
  - The **state of the animal**, not it's treatment
- Science based
- Varies on a continuum from very poor to excellent
- Ends at death

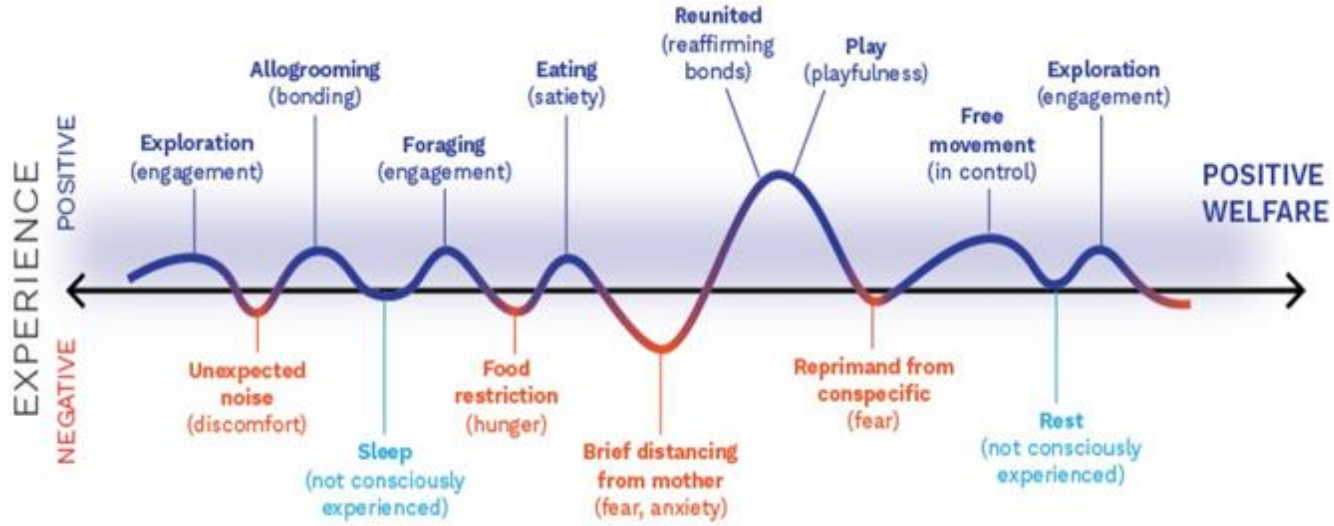
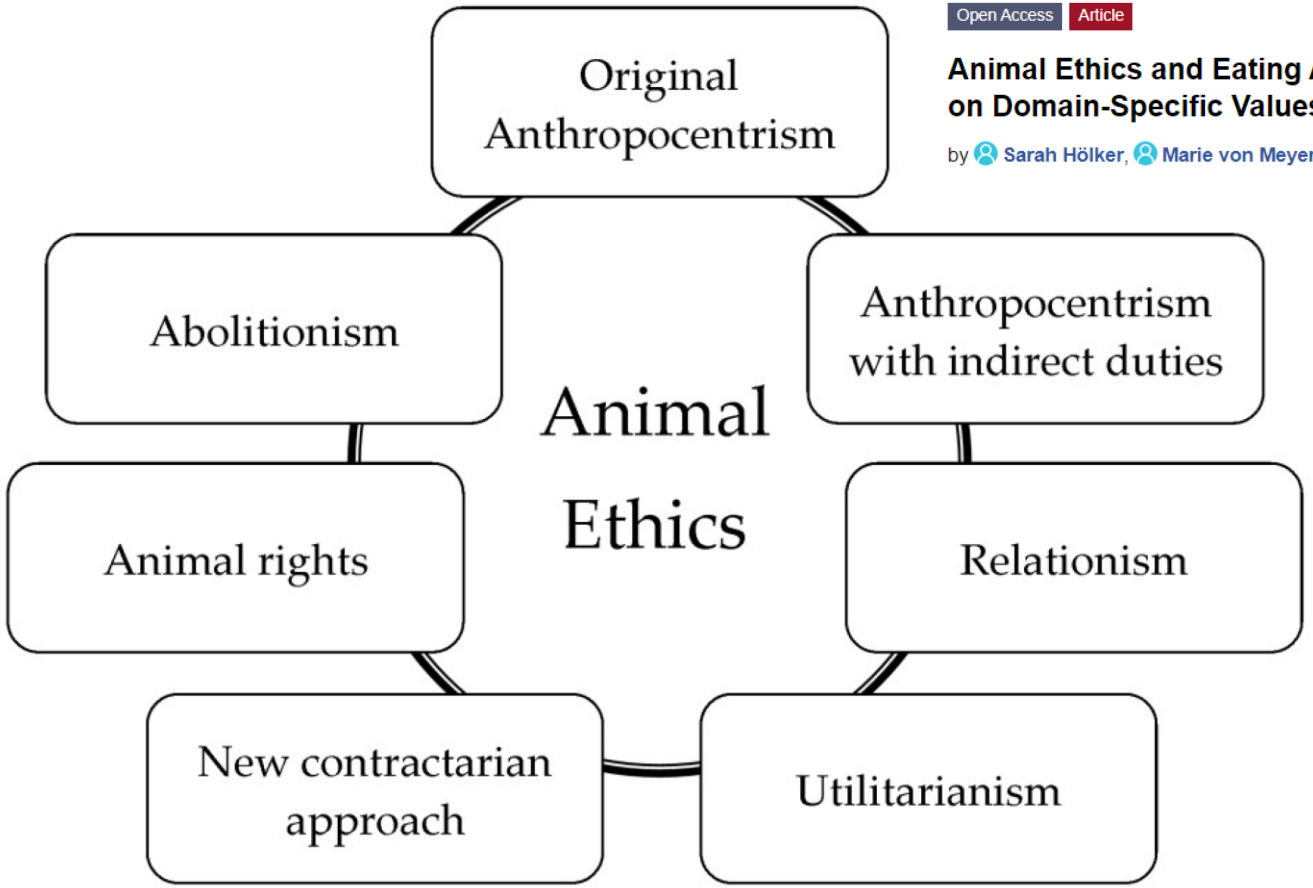


IMAGE SOURCE: https://zooaquarium.org.au/public/Public/Animal-Welfare/The-Five-Domains.aspx

Ethical Frameworks



Open Access Article

Animal Ethics and Eating Animals: Consumer Segmentation Based on Domain-Specific Values

by Sarah Hölker, Marie von Meyer-Höfer and Achim Spiller *

The Five Freedoms (Brambell, 1965)

- Freedom from hunger and malnutrition
- Freedom from discomfort
- Freedom from pain, injury, and disease
- Freedom to express normal behaviour
- Freedom from fear and distress

The Five Domains (Mellor and Reid, 1994)

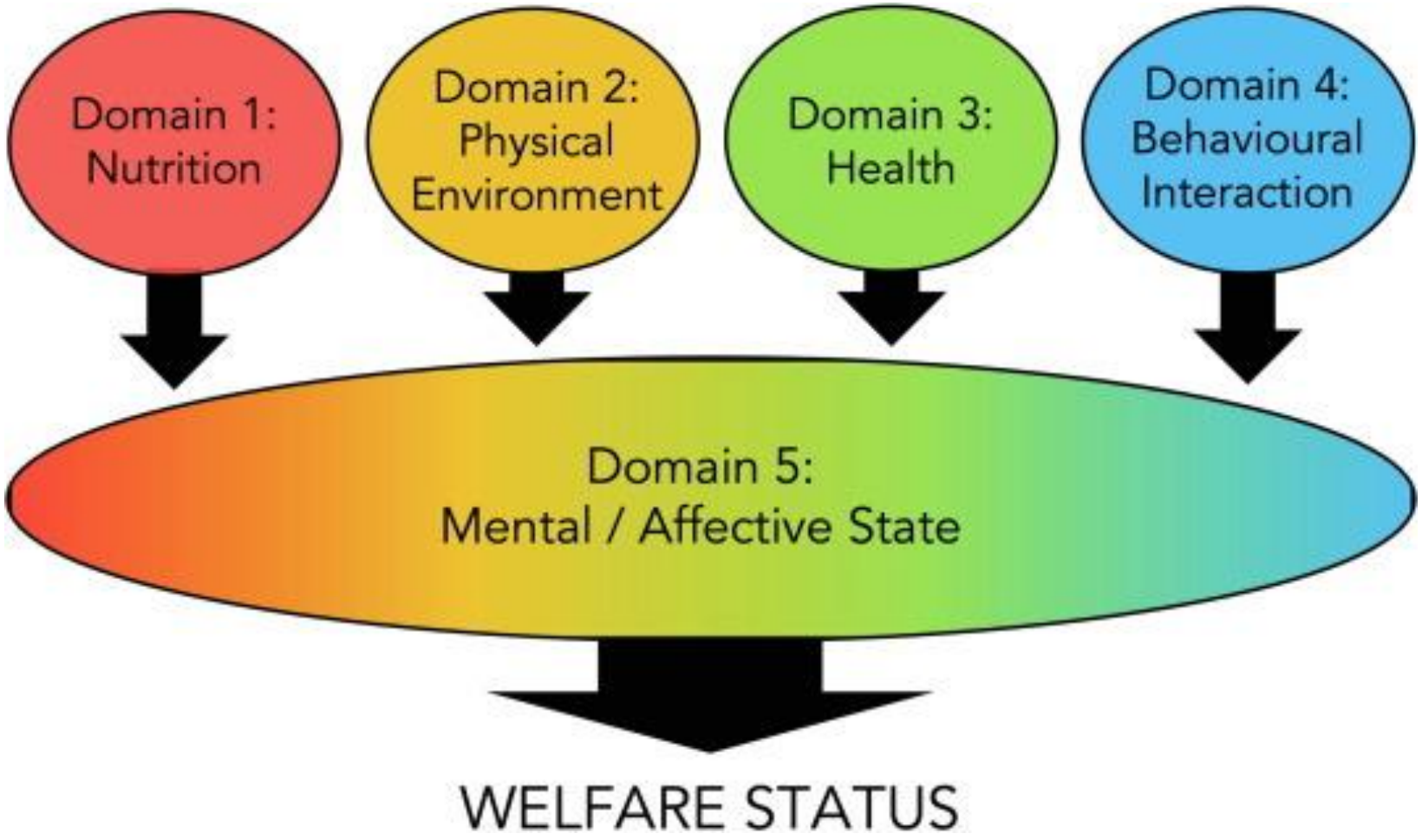


IMAGE SOURCE: https://www.sciencedirect.com/science/article/pii/S1751731121002214

Domain 5: Mental/Affective State

- How can I tell what an invertebrate is thinking or feeling?
- Physiological measures
  - Heart rate and heart rate variability
  - Stress hormone levels
- Cognitive assessments
  - Approach to novel objects
  - Cognitive bias
  - Spatial navigation tests
  - Operant conditioning (memory)

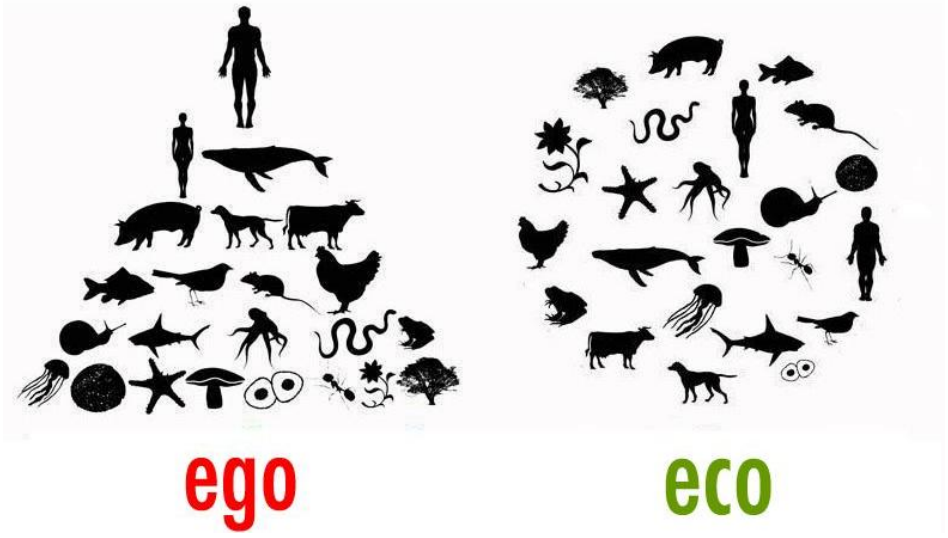
Domain 5: Mental/Affective State

We can focus on doing our best in domains 1-4 and keep making strides towards understanding the subjective experiences of invertebrates

Speciesm

Different levels of consideration are given to an animal's welfare as a **consequence of their species** rather than any **evidence**

Would this be acceptable in another species?



https://www.pinterest.com/pin/268808671483581835/

What is Sentience?

- The capacity to have feelings (Birch et al., 2021)
  - pain, pleasure, hunger, thirst, warmth, joy, comfort, excitement

- Subjective → not directly measurable

What is Pain?

Pain is an **aversive sensory and emotional experience** associated with actual or potential tissue damage, or described in terms of such damage

IASP
INTERNATIONAL ASSOCIATION FOR THE STUDY OF PAIN
CELEBRATING | 1974–2024

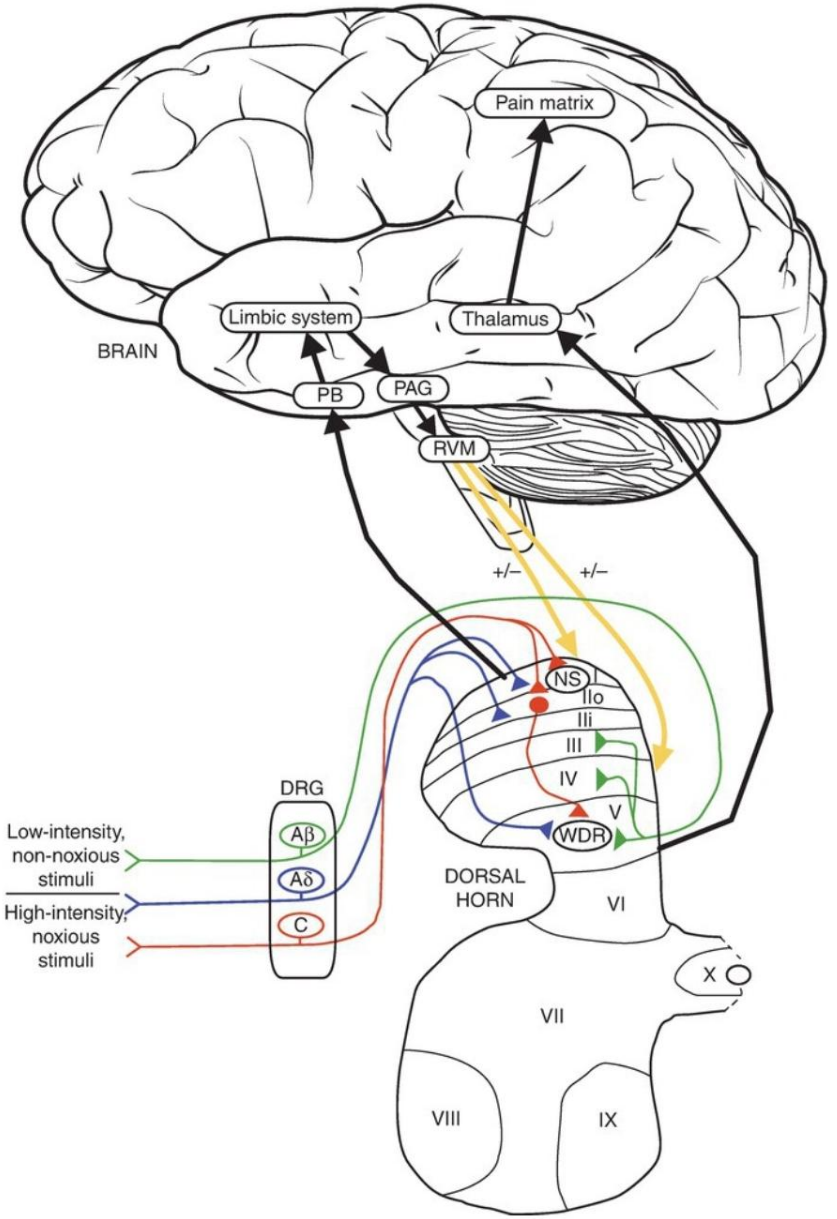
Pain vs Nociception

Pain

- Product of higher order brain center processing
- Emotional experience

Nociception

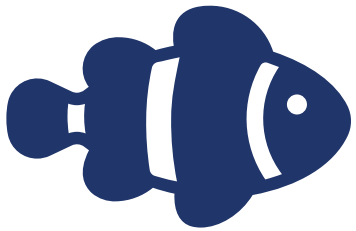
- Ability to detect noxious stimuli
- Nerve transmission
- Brain transmission to thalamus

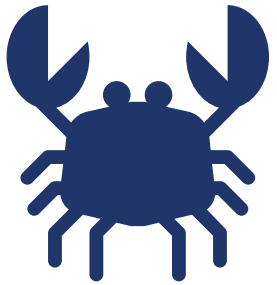


(Appleby et al., 2018, Animal Welfare, 3rd Ed.)

Sentience and Pain in Aquatic Animals

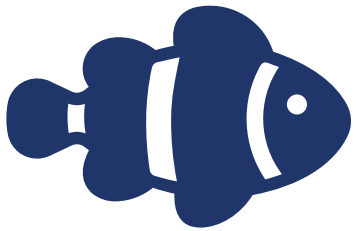
- Both are subjective, private experiences
- Some people debate if fish and aquatic invertebrates are sentient and have pain-sensation capacity
- Most evidence for fish, cephalopod molluscs, and crustaceans

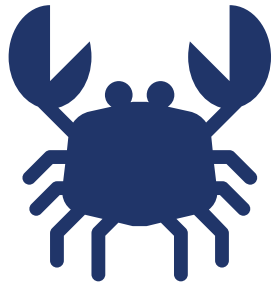




Sentience and Pain in Aquatic Animals

Definitively proven sentience or pain perception is not a pre-requisite for animal welfare considerations





Welfare Assessment

How do we assess animal welfare?

Animal Based Indicator

= Output

Resource Based Indicator

= Input

Operational Indicator

= Input

How do we assess animal welfare?

Animal Based Indicator

= Output

Resource Based Indicator

= Input

Operational Indicator

= Input

Individual	Population
Lesions	Amount of feed consumed
Behaviour	FCR

How do we assess animal welfare?

Animal Based Indicator

= Output

Resource Based Indicator

= Input

Amount of feed offered
Nutritional composition of feed
Water quality
Vaccines
Appropriate handling

Operational Indicator

= Input

How do we assess animal welfare?

Animal Based Indicator

= Output

Resource Based Indicator

= Input

Operational Indicator

= Input

Feeding SOP
Crowding/handling SOP
Filtration system design
Fish Health Plan
Vaccination certificate/record

How do we assess animal welfare?

THERE IS NO SINGLE PERFECT INDICATOR OF WELFARE

But how do we know what animals want or need?

- Longitudinal evaluation of different factors
  - How well do they do?
- What do they do in their natural environment? Can we use wild conspecifics?
  - Time budget analysis
  - Ethogram
- Preference testing
- Motivation testing

FIG. 1. A zebrafish preference test. The fish chose to spend more time in the half of the tank with gravel and a submerged plant, rather than sand with a floating plant. Photo credit: P. Schroeder. Color images available online at www.liebertpub.com/zeb

https://www.researchgate.net/publication/306293828/figure/fig1/AS:613919735418894@1523381279410/A-zebrafish-preference-test-The-fish-chose-to-spend-more-time-in-the-half-of-the-tank.png

Challenges in Aquatic Invertebrate Welfare

Good animal welfare in aquaculture requires:

- Good genetics
- Disease prevention
- Appropriate housing system
- Management that takes into account species needs
- Ability to express behaviours that are important to the animal
- Humane handling
- Minimising distress, including during transport
- Humane slaughter
- Choice and control

Challenges in Aquatic Invertebrate Welfare

- We know far less about aquatic invertebrates than terrestrial mammals
  - Very different experience than ours → Not “if I were a prawn”
  - Opportunities for research
  - May be hard to observe

https://www.worldfishing.net/new-horizons/europes-largest-shrimp-farm/1451535.article

Challenges in Aquatic Invertebrate Welfare

- Complex lifecycles
  - Doesn't happen in pond
  - Domesticated stocks
  - Developed systems to farm and house

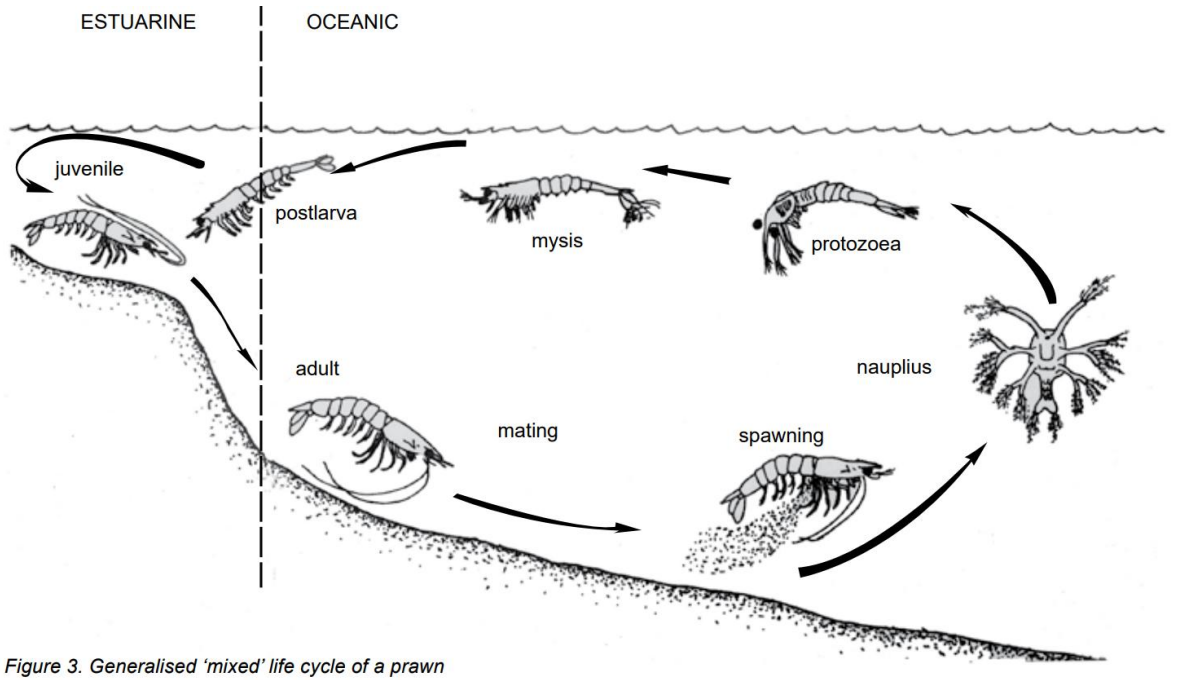


Figure 3. Generalised 'mixed' life cycle of a prawn

https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/358863/biology-and-life-cycles-of-prawns.pdf

Challenges in Aquatic Invertebrate Welfare

- Diversity of species
  - Roughly 40 species of decapod crustaceans farmed worldwide
  - Different sizes and anatomy
  - Different environments and needs
  - What is good welfare for one species is not necessarily good welfare for another!

Figure 1. Giant freshwater prawn (Macrobrachium rosenbergii)

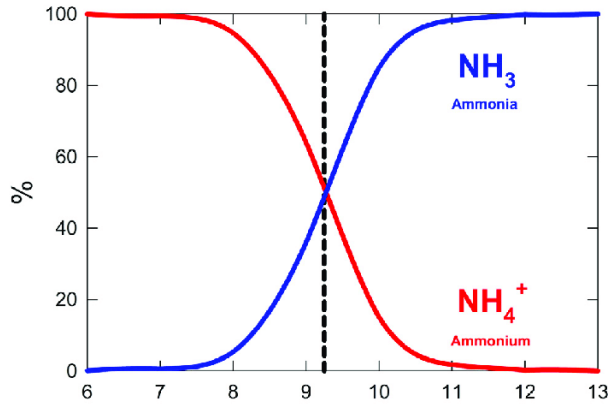
https://www.fao.org/fishery/affris/speciesz-profiles/giant-river-prawn/giant-river-prawn-home/en/

Figure 3: Juvenile *Penaeus monodon* juvenile, lateral view (courtesy of E. DeMuylder)

https://www.fao.org/fishery/affris/species-profiles/giant-tiger-prawn/giant-tiger-prawn-home/en/

Challenges in Aquatic Invertebrate Welfare

- Aquatic environment is complex
  - Factors are inter-related
    - E.g. ammonia concentration and toxicity increases as pH increases
  - Whole ecosystem in ponds
    - Zooplankton and phytoplankton act as food sources – can manipulate but do not have complete control
  - We cannot feasibly control **every** parameter



https://www.researchgate.net/publication/352518096/figure/fig4/AS:1035035001700352@1624021401046/Percent-abundance-of-ammonia-and-ammonium-across-a-range-of-pH-values-in-a-closed.png

Challenges in Aquatic Invertebrate Welfare

- Water quality
  - Not just the number but variability
  - Each species has different tolerances
    - Survival ≠ good welfare
  - Dissolved oxygen
  - pH, alkalinity, hardness
  - Temperature
  - Ammonia, nitrite, nitrate
  - Turbidity/suspended solids
  - Salinity
  - Water flow

https://static1.squarespace.com/static/5b62494e5b409b07d425879b/5b635fe5352f53987046243d/5eb5e1fc73ee2c27d7133008/1627942116369/How-Ammonia-Harms-Organisms-in-Aquaculture-Blog-Square-Image-compressed.jpg?format=1500w

Challenges in Aquatic Invertebrate Welfare

- The massive number of individual animals being farmed
  - 5,160,047 tonnes of crustaceans and 203,898 tonnes of molluscs farmed worldwide in 2022
  - 2017: Estimated to be 5-15 billion crabs, 37-60 billion crayfish and lobsters, and 213-530 billion shrimps and prawns (Mood and Brooke, 2019)

- Animal welfare considerations are often proportional to the value of the individual animal
  - The animal welfare considerations for less expensive species (e.g., prawns) are often less than that of high value species (e.g., lobsters)

Challenges in Aquatic Invertebrate Welfare

- But…
  - Many farmers really care about their animals
  - There are many people doing a great job!
  - Lots of changes and improvements in this space

https://www.discountpartysupplies.com.au/rainbow-cardboard-cutout-wall-decoration-raidecu01.html

Safeguarding Invertebrate Welfare

Safeguarding Invertebrate Welfare On-Farms

- Research to understand the needs of each species
  - Feeds
  - Water quality
  - Structure of environment
  - Stocking density

Contents lists available at ScienceDirect

Applied Animal Behaviour Science

journal homepage: www.elsevier.com/locate/applanim

Shelter limitations reduce forage frequency by affecting forage motivation in juvenile Pacific abalones (*Haliotis discus hannai*), but not in adults

Xuguang Hou [1], Fanchong Ren, Zhansheng Guo [2], Junxue Mei [*,3]

Marine College, Shandong University, Weihai, Shandong Province 264209, China

2023

animals 2023 MDPI

Article

Growth and Welfare Status of Giant Freshwater Prawn (*Macrobrachium rosenbergii*) Post-Larvae Reared in Aquaponic Systems and Fed Diets including Enriched Black Soldier Fly (*Hermetia illucens*) Prepupae Meal

Matteo Zarantoniello [1,*], Giulia Chemello [1], Stefano Ratti [1], Lina Fernanda Pulido-Rodríguez [2], Enrico Daniso [3], Lorenzo Freddi [4], Pietro Salinetti [1], Ancuta Nartea [5], Leonardo Bruni [2], Giuliana Parisi [2], Paola Riolo [5] and Ike Olivotto [1]

Received: 3 August 2020 | Revised: 3 May 2021 | Accepted: 15 June 2021

DOI: 10.1111/jwas.12830

APPLIED STUDIES

Journal of the World Aquaculture Society | WILEY

Use of different seaweeds as shelter in nursing mud crab, *Scylla paramamosain*: Effects on water quality, survival, and growth of crab

Khanh Ly Van | Cliford Polo Arsa | Ngoc Anh Nguyen Thi | Hai Tran Ngoc

Safeguarding Invertebrate Welfare On-Farms

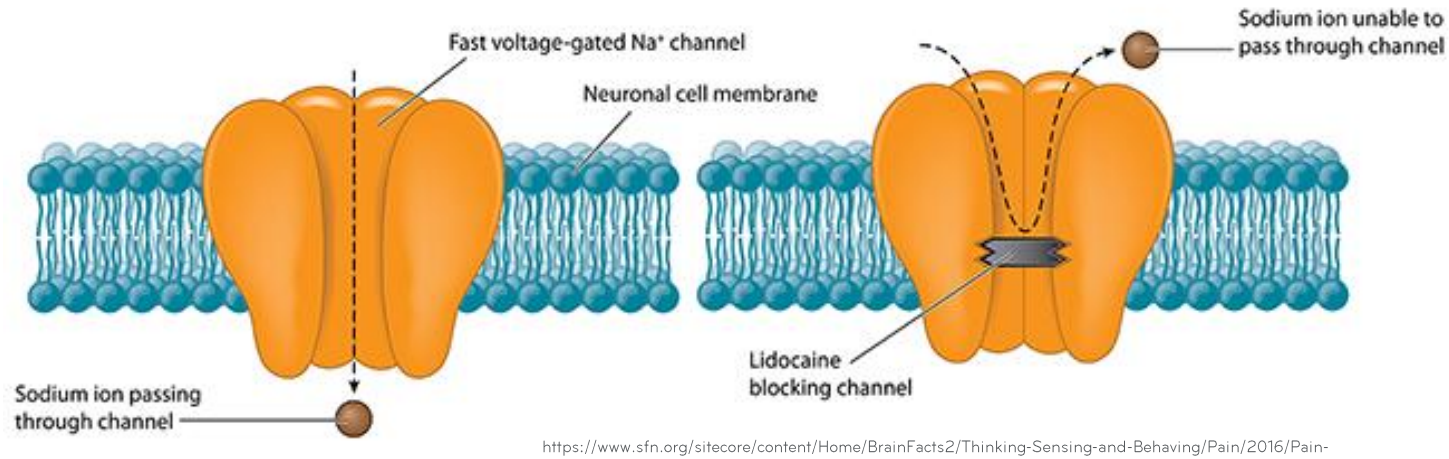
- Setting up plans and protocols
  - Biosecurity Plans
  - Fish Health Plans
  - Water quality monitoring and maintenance
  - Feeding and feed management
  - Handling

https://www.abc.net.au/news/2024-05-10/white-spot-detection-prawns-evans-head-nsw-north-coast/103829366

Safeguarding Invertebrate Welfare On-Farms

- Humane handling techniques
  - Anaesthesia
  - Analgesia
  - Staff training

Analgesia



https://www.sfn.org/sitecore/content/Home/BrainFacts2/Thinking-Sensing-and-Behaving/Pain/2016/Pain-Therapies-102516

Local anesthetics

- Conservation of sodium channels (Silva, 2020)
- Lidocaine (Butler-Streuben et al., 2018; Crook, 2021)
- Benzocaine (Barr et al., 2008)

Morphine → Sedation (Barr & Elwood, 2011)

Crown of Thorns Case Study

Crown of Thorns

- Corallivorous sea stars
  - Can consume up to 10m^2 coral/yr
  - Prefer faster growing corals
- Native to the Indo-Pacific
- Outbreaks (since 1962)
  - Increased larval survival
  - Removal of predators

https://theconversation.com/love-connection-breakthrough-fights-crown-of-thorns-starfish-with-pheromones-75779

https://www.aims.gov.au/research-topics/marine-life/crown-thorns-starfish

Crown of Thorns

- To decrease their numbers we:
  - Inject with bile salts or vinegar
  - Traps with pheromones
- Is this a humane death? Do they have the capacity to suffer?
- Does it matter that they're technically native?
- Does it matter that they're damaging a struggling ecosystem?

INNOVATION

Sea-Star Murdering Robots Are Deployed in the Great Barrier Reef

The RangerBot is a new line of defense against coral-eating crown-of-thorns starfish

Ashley Braun, Hakai Magazine

August 31, 2018

RangerBot is an autonomous underwater vehicle designed to identify and kill crown-of-thorns starfish by lethal injection. Photo courtesy of Queensland University of Technology

https://www.science.org/content/article/can-scientists-help-corals-killing-starfish

Humane Slaughter Case Study

Terminology

Euthanasia
Uses a method that minimizes pain and distress

Humane Killing
Is not performed to end an animal's suffering

Slaughter
Is killing an animal for consumption by humans or another animal

Humane Slaughter

- **Humane** = marked by compassion, sympathy, or consideration for humans or animals

- Rapid loss of sensibility
  = able to receive sensations
- Loss of brain function
- Minimizing anxiety, pain, and distress

Humane Slaughter

Stunning

- Loss of brain function
- Electric shock, percussive stunning, hypothermia

Killing

- Results in death
- Cutting gill arch (fish)
- Ice slurry

Humane Slaughter

- How do we currently slaughter invertebrates?
  - Ice slurry or very cold water
  - Rapid freezing (nitrogen or brine)
  - Dewatering
  - Freshwater (drowning)

https://jala.tech/blog/cultivation-tips/5-functions-of-ice-in-the-shrimp-harvest-distribution-process

Humane Slaughter

- Do not place in hot/boiling water until nerve centers destroyed
- Electrical stunners and hypothermic shock

https://thechefsforum.co.uk/top-chefs-give-seal-of-approval-to-crustastun/

https://optimar.no/solutions/product/optimar-shrimp-stunner#:~:text=Optimar's%20electric%20stunning%20system%20is,in%20a%20stress%2Dfree%20manner.

https://aceaquatec.com/news-and-resources/news/test-1

Humane Slaughter

- Challenges
  - Need to account for food safety
  - Need to maintain/improve product quality
  - How do we tell when the invertebrate is insensible?
  - How do we tell when the invertebrate is dead?

The efficacy of electrical stunning of New Zealand rock lobster (*Jasus edwardsii*) and freshwater crayfish (*Paranephrops zealandicus*) using the Crustastun™ 2023

Nikki J Kells[1,2], Matthew Perrott[1] and Craig B Johnson[1,2]

[1]School of Veterinary Science, Massey University, Palmerston North, New Zealand
[2]Animal Welfare Science and Bioethics Centre, Massey University, Palmerston North, New Zealand

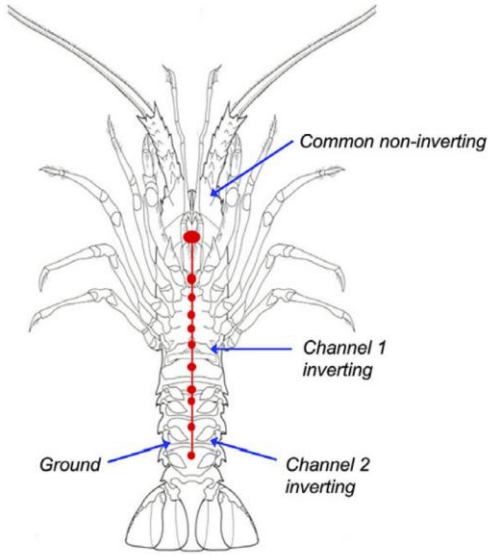


Figure 1. Ventral view of a rock lobster showing the approximate location of the central nerve cord and associated ganglia (red) and illustrating the sites of electrode placement (blue arrows) used for recording electrical activity from the nervous system of animals undergoing electrical stunning.

Wrap Up

Today's Presentation

1. What is animal welfare?
2. Welfare Assessments
3. Challenges in Aquatic Invertebrate Welfare
4. Safeguarding Invertebrate Welfare
5. Case Studies

Summary

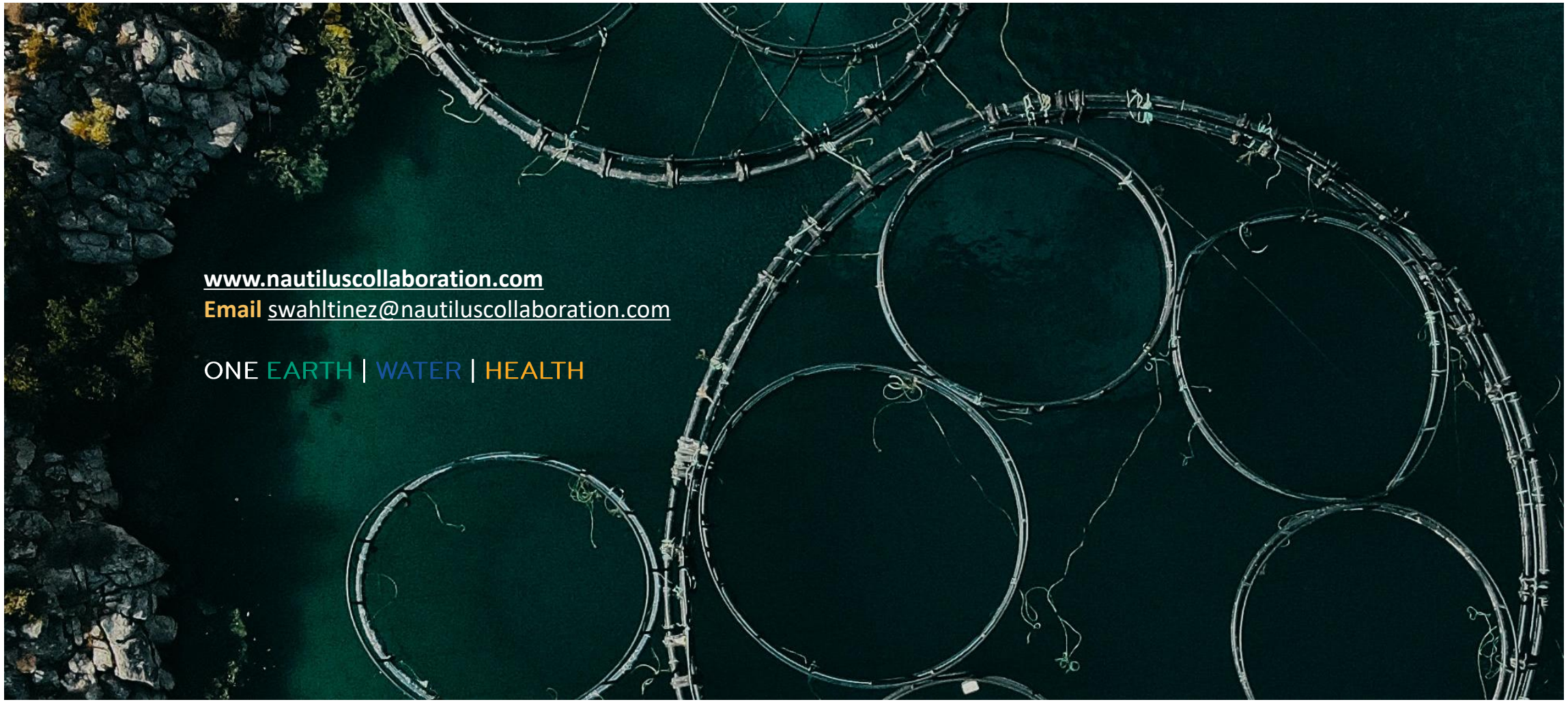
- Animal welfare encompasses an animal's physical wellbeing and experiences
  - And is an important part of responsible farming!
- Animal welfare indicators can be direct, indirect, or operational
- There are many challenges in aquatic invertebrate welfare including our lack of knowledge, the aquatic environment, complex life cycles and the sheer number of individuals
- Aquatic animal welfare is challenging but there are many people doing good work
- Words matter – use the correct terms

Where can we improve?

- **Think outside the box!** Creative approaches required
  - Challenge the status quo
- More research on what is important to aquacultured species
- Welfare research in diverse taxa
- Need information on humane culling and slaughter techniques

At the end of the day, small practical changes can have a huge impact on aquatic invertebrate welfare!

CONTACT | US


www.nautiluscollaboration.com
Email swahltinez@nautiluscollaboration.com
ONE EARTH | WATER | HEALTH