

## **Area of Scientific Expertise**

**Topic:** Invertebrate Aquaculture and Fisheries

### **Current State of Invertebrate Aquaculture and Fishery Research**

Invertebrate aquaculture and fisheries are prominent global food sources. Marine invertebrates form an essential component of the base of the ocean's food webs but have been increasingly exploited as human populations grow. However, research on the impact that overexploitation has on marine invertebrates and their ecosystems is rather limited (Flemming et al., 2011). Asian countries make up 89% of global aquaculture, but both production and research in aquaculture and fisheries are increasing in many countries, including the United States (Garlock, 2020).

Recent research in invertebrate aquaculture and fisheries is mainly focused on the ecology of fished and overfished ecosystems, the potential ecological benefit of invertebrate aquaculture, the impacts of climate change on fisheries, and the genetics and life history of fished species. Aquaculture has historically been stigmatized due to its association with the negative ecological impacts of finfish aquaculture. However, research on the aquaculture of invertebrates has indicated that it actually can promote ecological health through ecosystem goods and services, such as providing habitat for mobile macrofauna (Theuerkauf et al., 2022). Specifically, suspended coastal bivalve aquaculture (such as oyster and mussel production) has been found to be associated with higher abundance and species richness of macrofauna. There is also a growing set of literature on the effects of climate change and ocean acidification on shell building invertebrate fisheries. Finally, life history and culture research on specific invertebrate

species is advancing to develop better management of aquaculture and fisheries. For example, research on lactic acid bacteria in shellfish digestive tract has been shown to promote growth in shellfish and produce antibacterial substances toward fish pathogens (Ringø et al., 2020). Findings like this are critical for newer efforts like multi-trophic aquaculture systems where shellfish are cultured with or as food for finfish. Although the database of knowledge on invertebrate aquaculture and fisheries is growing, there are still several large challenges left to overcome.

One of the biggest barriers to progressing in this field is the underrepresentation of marine invertebrates in both IUCN reports and conservation efforts (Chen, 2021). Many invertebrate fisheries are impacted by overfishing, but oftentimes, little attention is given to the state of their populations. This can lead to extinctions of overfished organisms, like the white abalone. In addition, the politics of climate change can be a barrier to research in invertebrate aquaculture and fisheries. Despite these challenges, the field is still progressing globally, especially as aquaculture continues to expand as an industry. Some emerging techniques that I expect to see implemented in this field in the next several decades include eDNA analysis of invertebrate species, digital imaging of ecosystems, remotely operated vehicle (ROV) monitoring, and further behavioral research. I also expect that management of invertebrates will eventually change. Currently, there are questionable ethical considerations on the treatment of invertebrates that generally exclude them from the same level of treatment and care as vertebrates. This is due to the non-visible low cognition of invertebrates. I expect that as research on the behavior of fished and cultured marine invertebrates progresses, management will change to become more humane, more closely reflecting the treatment of vertebrates.

## **Top Researchers in Invertebrate Aquaculture and Fisheries**

In my research, I discovered that there are many researchers worldwide investigating aquaculture and fisheries. However, there are fewer scientists who specialize in invertebrates, and even fewer that limit their research efforts to only this topic. Many researchers in this realm will focus on a key species to focus their research and branch out to other topics in marine science that generally tie into aquaculture and fisheries, such as climate change. One such researcher is Dr. Symon Dworjanyn from Southern Cross University in Australia. Dr. Dworjanyn conducts research in several fields that are directly and indirectly related to invertebrate aquaculture. His research involves sustainable sea urchin and seaweed aquaculture, both part of growing industries. Dr. Dworjanyn is part of the intellectual camp of invertebrate aquaculture researchers that relate their research to the effects of climate change on marine invertebrates.

Another top researcher in marine aquaculture is Dr. Ricardo Calado. Rather than focusing on climate change, Dr. Calado centers his research around applied marine ecology and ornamental aquaculture of invertebrates. Adding the field of applied marine ecology to aquaculture results in conservation and restoration techniques of invertebrate populations, as well as coastal management of aquaculture and fisheries. This intellectual camp is another crucial aspect of aquaculture and fisheries, as it allows a venue to apply the knowledge gained from research to actual aquaculture practices. Additionally, ornamental aquaculture is another avenue of this field involved in the rearing of invertebrates for the aquarium trade.

Lastly, Dr. Ximing Guo from Rutgers University is an incredibly accomplished researcher who focuses primarily on oyster aquaculture and fisheries. Dr. Guo represents a third intellectual camp in the field of invertebrate aquaculture that is devoted to the genetic and breeding aspect of aquaculture. This side deals more with organism-specific culture and cannot

always be applied as widely as climate change research and marine ecology in the management of general or multi-trophic aquaculture. Molluscan aquaculture and fisheries also potentially make up the largest invertebrate taxa in this field with the most research and biggest industry.

Since aquaculture and fisheries are widespread global industries, I did not limit my search to solely the United States. Collaboration between researchers would be more visible if I identified the top researchers by country. However, while the United States does have its hand in aquaculture and fishery research, the reality is that other countries are far ahead of the US in this field. It would be unrealistic to assume that U.S. scientists are the top of this field when in reality, other countries rely on aquaculture and fisheries more heavily and thus produce more research.

## References

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